EVIDENCE ON THE SURGICAL MANAGEMENT OF OBSTRUCTIVE SLEEP APNOEA IN ADULTS WITH FOCUS ON UVULOPALATOPHARYNGOPLASTY: A SCOPING REVIEW

Winile Patricia Makhaye

203508809

A dissertation submitted in fulfillment of the academic requirements for the degree of Master of Medicine
in the Department of Otorhinolaryngology-Head and Neck Surgery, School of Clinical Medicine, University of Kwa-Zulu Natal

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This dissertation is presented in a manuscript format

This is to certify that the contents of this thesis are the original research work of Winile Patricia Makhaye. As the candidate's supervisor, I have approved this thesis for submission.

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Supervisor: -

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DECLARATION - PLAGIARISM

I, Winile P. Makhaye, declare that: -

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DEDICATION

This dissertation is dedicated to my daughter, Ntandoyenkosi Shange, for being my greatest motivation and support.

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ABSTRACT

Background: Over the years, various treatment options have been recommended to patients to manage obstructive sleep apnoea (OSA). This study aims to systematically map recent evidence on surgical management of obstructive sleep apnoea in adults with a focus on uvulopalatopharyngoplasty

Methods: This study used a scoping review method guided by Arksey and O'Malley (2005). An electronic database search has been conducted and the databases found were as follows: PubMed, Google Scholar, CINAHL, Health Source, and Medline with full text via EBSCO host. We searched for studies published from 2015 to 2019 that presented evidence on the surgical management of OSA in adults with a focus on UPPP. We screened titles from retrieved studies after completing the database searches and removed duplicates. Two screeners reviewed abstracts and full articles in parallel, guided by eligibility criteria. Emerging themes were extracted from the included studies. The Mixed Method Appraisal Tool (MMAT) 2018 was used to assess the primary studies' quality.

Results: A total of 1,762 articles were identified and screened, of which 16 were included in this review for total data extraction. The studies included collectively reported on oropharyngeal procedures for OSA management, which included modifications to UPPP. All included studies were published between 2015 and 2019. There was limited literature from LMIC's. Included studies were conducted in different countries and are as follows: Iran, Egypt, Malaysia, Taiwan, Brazil, Turkey, Italy, Korea, USA, and Germany. Procedures performed as alternatives to UPPP resulted in improved outcomes based on absolute Apnea-Hypopnea Index (AHI) and Epworth Sleepiness Scale (ESS). Procedures specifically targeting tongue base obstruction or involving tonsillectomy were identified as resulting in better overall outcomes.

Conclusion: UPPP remains a valid surgical option for the management of OSA, but alternative procedures aimed at multi-level approaches, tonsillar obstruction, and relief of tongue-based obstruction are gaining favor. These improved overall outcomes suggest that alternative surgical techniques to UPPP, either alone or in combination with UPPP, should be considered to improve overall postoperative outcomes.

Keywords: Obstructive Sleep Apnoea. Sleep disorders. Surgical procedure. Uvulopalatopharyngoplasty. Apnoea-Hypopnea Index. Scoping review.

DEFINITIONS

Apnoea – cessation of airflow for at least 10 seconds with oxygen desaturation or an arousal from sleep [1]

Apnoea Hypopnoea Index (AHI) - the number of obstructive airway events per hour of sleep. AHI < 5 is considered normal. AHI 5 - 15 is mild OSA; 15 - 30 AHI is moderate OSA, and an AHI > 30 indicates severe OSA [2]

Continuous Positive Airway Pressure – primary treatment for OSA. Makes use of face or nasal mask connected to a machine and at a set, pressure-assist in the prevention of upper airway collapse during sleep [3]

Epworth Sleep Score - a simple self-administered questionnaire designed to measure a subject's general level of daytime sleepiness (Johns, 1991). The subject is asked to rate on a scale of 0–3 the chances that over recent times they would have dozed in eight specific situations [4]

Hypopneas – an abnormal respiratory event lasting ≥ 10 sec with ≥ 30% reduction in thoraco-abdominal movement or airflow, and with ≥ 4% oxygen desaturation [11]

Laser-Assisted Uvuloplasty - is a surgical procedure that relies on the use of a carbon dioxide (CO2) laser to vaporize the uvula and a part of the free edge of the soft palate during one to several sessions [5]

Obstructive Sleep Apnoea Syndrome - is defined by the presence of at least a minimum number of obstructive apneas and hypopneas per hour of sleep and the presence of mental or physical effects (or both) that result from the respiratory disturbances [6]

Sleep study/polysomnography - is a recording of multiple physiologic parameters relevant to sleep. Traditionally, clinical studies have used a typical recording montage that includes electroencephalography (EEG), electrooculography (EOG), chin electromyography (EMG), respiratory effort, airflow, electrocardiography (ECG), oximetry, and anterior tibialis EMG [7]

Sleep-disordered breathing - a condition characterized by repeated pauses in breathing during sleep, which lead to the fragmentation of sleep and decreases in oxyhemoglobin saturation [8]

Scoping Review - a tool that can be used to map literature of a specific topic and present clear evidence of what is found in the studies available [9]

Uvulopalatopharyngoplasty (UPPP) – the most common surgical procedure for patients with OSA, involves removing the tonsils (if present), uvula, distal margin of the soft palate, and any excessive pharyngeal tissue. [10]

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ACRONYMS AND ABBREVIATIONS

AHI	Apneoa-Hypopneoa Index
BMI	Body Mass Index
CPAP	Continuous Positive Airway Pressure
MMAT	Mixed-Method Appraisal Tool
OSA	Obstructive Sleep Apnoea
OSAHS	Obstructive Sleep Hypopnea Syndrome
UCTD	Union Catalogue of Thesis and Dissertations
UKZN	University of Kwa-Zulu Natal
UPPP	Uvulopalatopharyngoplasty

CHAPTER 1: OVERVIEW AND BACKGROUND OF THE DISSERTATION

1.1 Background

Obstructive Sleep Apnoea (OSA) implies the complete or partial obstruction of the airway during sleep that causes airflow cessation (apnoea) or airflow reduction (hypopnoea) despite the resulting increase in breathing effort [11]. The prevalence of this disorder increases with age, and globally, it is estimated to be commonest in men, affecting 62 % of older men over 65 years old [12]. Along with a decrease in stimulations that maintain pharyngeal tone, anatomical disorders (e.g., tongue and pharyngeal tissue increases, palate displacement) cause obstruction in the airways resulting in apnoea-hypopnoea episodes. OSA can be associated with multiple comorbidities, such as an increase in blood pressure and metabolic syndrome [13]. Obstructive Sleep Apnoea results in daytime sleepiness, potentially resulting in significant safety implications such as an increase in driving crashes [14]. The gold standard for diagnosing this disease is split-night polysomnography (PSG) which studies patient sleep cycle during the night [15].

Over the years, various treatment options have been recommended to patients to help them manage OSA symptoms. A lifestyle change (weight loss, no alcohol consumption, no smoking, and no sedative-hypnotic drugs) is recommended [16]. Continuous positive airway pressure (CPAP) therapy is usually prescribed as first-line treatment. However, some patients find it challenging to adhere to CPAP therapy for reasons such as nasal discomfort and mask leaks [17].

Surgery is reserved as second-line treatment in OSA management, especially for patients who do not tolerate CPAP. Uvulopalatopharyngoplasty (UPPP) is one of the first procedures to be developed for the surgical management of OSA; it is extensive surgery performed with the aim of removing the palatal and lateral pharyngeal tissues that collapse during sleep in persons with OSA [18]. UPPP's success ranges from 30% to 60%, depending on factors such as whether it was performed with or without tonsillectomy [19]. Over the years, newer procedures to target different sites of the oropharynx have been developed in an ever evolving surgical field whose trajectory is shifting towards developing less invasive but equally effective surgical procedures. As a result, the surgical management of OSA, and in particular the role of UPPP, remains an area of much debate and controversy. Therefore, this study aimed to map the current, last five years, literature on UPPP's role in OSA.

We employed a scoping review research methodology to map out current evidence on the use of UPPP as a stand-alone procedure or in combination with other oropharyngeal procedures [including those of the tongue base] to manage OSA in adults, and also be able to reveal gaps in the literature and make recommendations for future research.

1.2 Aim of the study

The current study aimed to map the global literature on surgical management of Obstructive Sleep Apnoea in adults, focusing on uvulopalatopharyngoplasty.

1.3 Objectives of the study

- To determine current evidence regarding the use of UPPP as a stand-alone procedure or in combination with other oropharyngeal procedures for the management of OSA in adults.
- To reveal gaps in research on the modifications of UPPP and their post-operative outcomes on the surgical management of OSA.

1.4 Problem statement

Approximately 1 billion of the world's population of 7.3 billion people, between the ages of 30 and 69 years, are estimated to have the most common type of sleep-disordered breathing, Obstructive Sleep Apnoea (OSA) [38]. Its prevalence is rising and affects all countries. The increase in prevalence is driven by the global rise in obesity, the major risk factor for OSA [39]. Continuous positive airway pressure (CPAP) remains the first line of treatment in these patients. However, it can only provide relief when used appropriately. Pinto *et al*. reported that compliance remains a significant problem in inpatient and outpatient settings despite several CPAP therapy benefits. And this is generally due to patient discomfort with the CPAP mask [16]. Surgery, therefore, becomes an alternative for those patients who struggle to tolerate CPAP. This study aims to map out evidence on the use and current modifications to UPPP, a historical surgical procedure for OSA management.

1.5 Significance

It is expected that the results of this study will guide future research and practice for the benefit of patients, primary health care practitioners, and otolaryngologists affected or managing obstructive sleep apnoea in adults.

1.6 Overview of this dissertation

This section gives a summary of each of the three chapters in the current thesis;

Chapter 1: Overview and background of the dissertation

The first chapter gives background information on the current knowledge about sleep disorders and Obstructive Sleep Apnoea. It shares the aim of the current study plus objectives that made it significant for the research to be conducted. An overview of the literature on OSA and its treatment options is also presented in this chapter.

Chapter 2: A Scoping Review of Evidence on Surgical Management of Obstructive Sleep Apnoea in Adults: A focus on Uvulopalatopharyngoplasty

The second chapter presents the results of the scoping review, achieving the study aim, which was "to map evidence of surgical management of obstructive sleep apnoea in adults with a focus on Uvulopalatopharyngoplasty." In this chapter, the results are represented as a manuscript, which will be submitted to a DHET accredited peer-reviewed journal at the end of the examination process.

Chapter 3: Synthesis

The third chapter puts together and links all the work done in the first two chapters. The summary of the research project is presented; findings are also highlighted and the study's strengths and limitations. This chapter includes the conclusion that connects the research findings with the aims and the objective; that is followed by recommendations for future research based on the gaps identified in the literature.

1.7 Literature Review

1.7.1 Introduction

Sleep-disordered breathing affects 20 to 30% of adults in America. The *International Classification of Sleep Disorders* (ICSD) 2014 edition has classified sleep disorders into the following categories; 1. Insomnia; 2. Sleep-related breathing disorders; 3. Central disorders of hypersomnolence; 4. Circadian rhythm sleep-wake disorders; 5. Parasomnias; and 6. Sleeprelated movement disorders [20]. Obstructive Sleep Apnoea is a severe form of sleep-related breathing disorder that may progress from simple snoring. Barnes, Drake *et al*. reported that reasons for people not getting healthy sleep are rooted from a young age. They explained that schools start too early, and as a result, children do not get the recommended daily sleep time of at least 10 hours [21]. In the same study, they further narrated that the routine continues to adulthood, where it is followed by working hours that result in adults not getting the recommended 7 to 8 hours of daily sleep [21].

1.7.2 Diagnosis of OSA

People showing obvious symptoms such as snoring and fatigue are encouraged to undergo a medical diagnosis. Although snoring may be the most obvious symptom of OSA; it is advised that patients visit a sleep specialist for diagnosis to be made utilizing polysomnography [22,23]. During this evaluation, the patient's daily sleepiness level is measured; and physical examination of the upper airway is also performed [24]. In a systematic review by the Nordic project, they reported that an individual with OSA has to show the following symptoms, *among other things*; daytime sleepiness that is not caused by other factors; waking up unrefreshed from

sleep; daytime fatigue; and five or more incidences of apnea or hypopnea per hour during in an evaluation [25].

The Apnea-Hypopnea Index (AHI) is a metric used to measure disordered breathing while the patient is asleep. It measures the number of apneas or hypopneas occurring during a sleep period divided by the number of hours slept [26]. This index is calculated using the polysomnography (PSG) results, where the presence and severity of OSA are determined (Image 1). The respiratory sensors are used to detect whether an apnoea or hypopnoea incident occurred; then, the number of times it occurred is recorded. Both the apnea and hypopnea incidences must last for a minimum of 10 seconds [13,26] to be counted.

AHI	Rating
<5	Normal (no Sleep Apnea)
5-15	Mild Sleep Apnea
15-30	Moderate Sleep Apnea
>30	Severe Sleep Apnea

Image 1: Apnea-Hypopnea Index

1.7.3 Management of OSA

The management of OSA requires a multidisciplinary approach where both behavioral and medical interventions are used. Behavioral changes include a healthier choice of food coupled with an exercise routine in obese patients; it also means that those who smoke should be advised to stop smoking, and excessive alcohol intake should be discontinued. However, due to lack of compliance [and limited success] of this approach, it is usually paired with other procedures as part of a treatment routine [27]. Regardless of the estimation that about 20 to 40% of OSA patients are not obese, obesity is still considered a significant cause for OSA; hence a lifestyle transformation is a top priority in those who are obese [28]. Alcohol and nicotine cause relaxation of airway muscles when an individual is asleep; these should also be taken in moderation for the treatment of OSA to be successful [29].

Continuous Positive Airway Pressure is the first line medical intervention in the management of OSA. Continuous Positive Airway Pressure (CPAP) is generally applied through the nose, and it has been reported to reduce AHI and, consequently, sleepiness during the day [30]. When non-invasive treatment measures fail or the patient cannot tolerate them, surgery becomes the

second-line option. Surgical procedures are performed with the aim of reducing airway resistance during sleep and to completely or near completely stop the collapse in the upper airway; this is done without causing any significant morbidity [30].

1.7.4 A closer look at Uvulopalatopharyngoplasty (UPPP)

Uvulopalatopharyngoplasty is one of the commonest surgical procedures for the management of OSA in the adult population, and it was first described by Fujita *et al*. in 1981 [30]. The procedure entails removing the palatine tonsil, uvula; a portion of the soft palate; and the lateral pharyngeal wall [31]. UPPP's success is measured by the reduction of a patient's AHI; when a patient has an AHI of less than 5, they are considered to be cured [32]. Patients with AHI of between 5 – 15 often do not show apparent clinical symptoms of OSA, while those with AHI of 30 and above experience severe symptoms (Image 1) [33].

In the review by Spicuzza *et al.*, it was reported that the success rate of UPPP could be estimated at around 30% when the procedure is performed alone; and 60% when it is coupled with tonsillectomy [18]. A controlled trial conducted on 65 patients with moderate to severe OSA showed a 60% improvement in the AHI of participants in the experimental group; this was a great improvement compared to those in the control group and did not undergo the surgical procedure [34]. In patients with the problem of snoring, UPPP has been used in the hope of eliminating it; it has, however, resulted in an improvement of between 50 and 70% in the study by Safaya *et al.* [19]. This improvement brings a level of relief for the affected patients and improves the quality of life [19]. In their randomized clinical trial on the changes in sleepiness and quality of life after modified UPPP, Browaldh *et al.* showed that modified UPPP (which included a tonsillectomy) effectively improved daytime sleepiness and quality of life in OSAS patients [35].

1.7.5 Impact and burden of OSA

Obstructive Sleep Apnea is a sleep disorder that does not only have a negative impact on the patient's quality of life, but it is also costly when not treated, and the affected person may end up being involved in a car accident due to the resultant fatigue and day time sleepiness [36]. It is also burdensome to the country's economy, where the morbidity and mortality rate is increased due to untreated patients who end up with adverse health effects to be managed. Kapur *et al*. reported a difference of $1 336 between untreated and treated OSA patients in their study, where those who left OSA untreated spent $1 336 more on their medical costs within one year [37]. There is limited literature from the middle to low-income countries, including Sub-Saharan Africa, regarding the specific prevalence, disease burden, and cost analysis for comparisons between undiagnosed, untreated, and treated OSA cases. This gap in the literature means the burden of disease is unknown. Therefore, it is difficult for policy makers to develop

management strategies suitable for limited resource countries to manage these patients and develop comprehensive, resource-appropriate holistic management options.

1.8 Methodology

1.8.1 Study design

We conducted a systematic scoping review to map evidence of the surgical management of OSA in adults, with a focus on UPPP and other oropharyngeal procedures that have been used in the past five years (2015-2019). Scoping review methods have been proposed by Arksey and O'Malley (2005) [40], and further advanced by Levac, Colquhoun, and O'Brien (2010); they follow a structured, systematic evaluation of existing literature that is meant to be reproducible. It aims to map this existing literature in a field of interest regarding the volume, nature, and characteristics of the primary research. As scoping reviews provide a rigorous and transparent method for mapping research areas, they can be used as a stand-alone project or as a preliminary step to a systematic review [40, 41]. It broadly follows these steps: -

1. Identification of research question

2. Identification of relevant studies

3. Selection of relevant studies

4. Data charting

5. Result collation, summarizing, and reporting.

A detailed account of the steps mentioned above is given in the methodology section of chapter 2 of the dissertation. In this scoping review, we included an additional step; methodological quality assessment of the primary studies, as recommended by Levac, Colquhoun, and O'Brien (2010) review [42]. We reported the results following the PRISMA ScR (Preferred Reporting Item for Systematic reviews and Meta-Analyses extension for Scoping Reviews) guidelines.

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CHAPTER 2: A SCOPING REVIEW OF EVIDENCE ON SURGICAL MANAGEMENT OF OBSTRUCTIVE SLEEP APNOEA IN ADULTS: A FOCUS ON UVULOPALATOPHARYNGOPLASTY

The previous chapter presented a brief and concise background to the research, aims, and objectives of the study; plus, a literature review that provided a brief overview of the dissertation structure. The current chapter presents the results obtained from the scoping review, which aimed to map the evidence on surgical management of OSA in adults with a focus on UPPP.

A Scoping Review of Evidence on Surgical Management of Obstructive Sleep Apnoea in Adults: A focus on Uvulopalatopharyngoplasty

Winile Makhaye[1], Andile Sibiya[1]; Zachary Porterfield[1,3], Tivani Mashamba-Thompson[2]

[1]Department of Otorhinolaryngology, School of Medicine, University of KwaZulu-Natal, KwaZulu-Natal Province, South Africa

[2] Faculty of Health Science, University of Pretoria, Pretoria, South Africa

[3]Department of Otolaryngology-Head and Neck Surgery, University of Kentucky, Lexington, Kentucky, United States of America

Corresponding author: Winile Makhaye

Address: Department of Otolaryngology-Head and Neck Surgery

Nelson R. Mandela School of Medicine

University of Kwa-Zulu Natal

Durban, South Africa

Email: winilemakhaye@gmail.com

ABSTRACT

Background: Over the years, various treatment options have been recommended to patients to manage obstructive sleep apnoea (OSA). This study aims to systematically map recent evidence on surgical management of obstructive sleep apnoea in adults with a focus on uvulopalatopharyngoplasty

Methods: This study used a scoping review method which was guided by Arksey and O'Malley (2005). An electronic database search has been conducted and the databases found were as follows: PubMed, Google Scholar, CINAHL, Health Source, and Medline with full text via EBSCO host. We searched for studies published from 2015 to 2019 that presented evidence on the surgical management of OSA in adults with a focus on UPPP. We screened titles from retrieved studies after completing the database searches and removed duplicates. Two screeners reviewed abstracts and full articles in parallel, guided by eligibility criteria. Emerging themes were extracted from the included studies. The Mixed Method Appraisal Tool (MMAT) 2018 was used to assess the quality of the primary studies, which were included.

Results: A total of 1,762 articles were identified and screened, of which 16 were included in this review for full data extraction. The studies included collectively reported on oropharyngeal procedures for OSA management, which included modifications to UPPP. All included studies were published between 2015 and 2019. There was limited literature from LMIC's. Included studies were conducted in different countries and are as follows: Iran, Egypt, Malaysia, Taiwan, Brazil, Turkey, Italy, Korea, USA, and Germany. Procedures performed as alternatives to UPPP resulted in improved outcomes based on absolute Apnea-Hypopnea Index (AHI) and Epworth Sleepiness Scale (ESS). Procedures specifically targeting tongue base obstruction or involving tonsillectomy were identified as resulting in better overall outcomes.

Conclusion: UPPP remains a valid surgical option for the management of OSA, but alternative procedures aimed at multi-level approaches, tonsillar obstruction, and relief of tongue-based obstruction are gaining favor. These improved overall outcomes suggest that alternative surgical techniques to UPPP, either alone or in combination with UPPP, should be considered to improve overall postoperative outcomes.

Keywords: Surgical management; Obstructive sleep apnoea; Uvulopalatopharyngoplasty; Adults; Apnoea Hypopnoea Index; Polysomnography.

2.1 Background

Obstructive sleep apnoea/hypopnea syndrome (OSAHS) is a common disorder characterized by a repetitive episodic collapse of the upper airway and intermittent hypoxia during sleep affecting nearly 1 billion people worldwide [2,43]. For patients with moderate-to-severe Obstructive Sleep Apnoea (OSA), Continuous Positive Airway Pressure (CPAP) therapy is usually prescribed as first-line treatment. This is supported by high-level evidence for the efficacy of CPAP in preventing upper airway collapse and relieving symptoms such as daytime sleepiness. Additionally, there is evidence to suggest that CPAP improves cardiovascular outcomes for OSA patients [44,45]. However, many patients find it challenging to adhere to CPAP therapy, prompting a substantial proportion to seek alternative treatment, including upper airway surgery [30]. Approximately 50% of patients stop using CPAP within the first year for various reasons; lack of knowledge about the benefits versus side effects; the need for regular follow-up visits; and adverse effects, including allergic reactions, difficulty exhaling, inability to withstand higher CPAP settings, and air swallowing with gastric distension [46]. Upper airway surgery is an alternative for patients that do not tolerate CPAP. Uvulopalatopharyngoplasty (UPPP) is one of the most commonly performed surgical procedures for OSA. First described by Fujita et al. in 1981, this report represented a significant surgical advancement in OSA management [46]. A 50% decline in the post-operative ApnoeaHypopnea Index (AHI) after UPPP was found in this study. Subsequently, many articles have reported UPPP success rates that varied from 25% to 85% [48,49].

Despite the positive post-operative outcomes reported, complications have also been reported, such as foreign body sensation, velopharyngeal insufficiency, and nasopharyngeal stenosis [50]. Obstructive Sleep Apnoea is increasingly being recognized as a multi-level disorder. In recent years, it has been shown that oropharyngeal obstructions, especially at the tongue base, lead to more severe respiratory distress than soft palate obstruction, and the incidence of tongue base obstruction is higher in severe forms of OSA [39]. This concept has led to the gathering momentum of surgeries targeting the tongue base in the last decade [39]. In this study, we aimed to perform a systematic scoping review on the current evidence on the use of UPPP and its variations as a stand-alone procedure or in combination with other oropharyngeal procedures, including those of the tongue base to manage OSA in adults. This study examines the most recent literature published between January 2015 - December 2019. The review revealed gaps in the literature, and recommendations for future research were outlined.

2.2 Methodology

2.2.1 Study design

We conducted a systematic scoping review to map evidence on Obstructive Sleep Apnoea's surgical management in adults, focusing on uvulopalatopharyngoplasty (UPPP) as reported between January 2015 to December 2019. The review was guided by the Arksey and O' Marley framework (2005), which stipulates the following five steps:

1. Identification of research question
2. Identification of relevant studies
3. Selection of relevant studies
4. Data charting
5. Result collation, summarising, and reporting

In this scoping review, we included an additional step, methodological quality assessment of the primary studies included as recommended by Levac, Colquhoun, and O'Brien (2010) review [42]. We reported the results following the PRISMA ScR (Preferred Reporting Item for Systematic reviews and Meta-Analyses extension for Scoping Reviews) guidelines [51].

Identified research question

The research question is: What is the current evidence on UPPP use as a stand-alone procedure or in combination with other oropharyngeal procedures for the management of OSA in adults?

The research sub-questions are as follows:

1. What variations of UPPP have been developed in the past five years (January 2015–December 2019)?
2. Are the post-operative outcomes of UPPP and/or its variations comparable to those of other oropharyngeal procedures for OSA?
3. Is preoperative polysomnography done in all patients before oropharyngeal surgery for OSA?

To determine the eligibility of the research question, we used the Population, Concept, Context (PCC) nomenclature (Table 2.1)

Table 2.1 A PCC Framework for eligibility of the research question for a scoping review

Determinant	Description
Population	Patients with obstructive sleep apnoea.
Concept	Uvulopalatopharyngoplasty as stand-alone or in combination with other oropharyngeal procedures for the management of OSA. UPPP involves resection of the uvula, distal margin of the soft palate, palatine tonsils, and any excessive lateral pharyngeal tissue.
Context	In the context of adults. We define adults as per the WHO definition of 19 years of age or above. Obstructive sleep apnoea can also affect children, but studies reporting on children will be excluded.

Identifying the relevant studies

We conducted an extensive search of the following electronic databases: PubMed/MEDLINE; Google Scholar; Union Catalogue of Theses and Dissertations via SABINET Online; and World Cat Dissertations and Theses via OCLC. The keywords during database search were as follows: Obstructive Sleep Apnoea (OSA); uvulopalatopharyngoplasty (UPPP); laser-assisted uvulopalatoplasty; and Apnoea-Hypopnea index (AHI). Boolean terms (AND OR) were used to separate the keywords. A hand search through the primary published texts used in otorhinolaryngology teaching and practice was also conducted. Additional searches of the reference list of included studies through the 'Cited by' links of the included studies were undertaken. In our search for eligible studies, the MESH (Medical Subject Headings) was utilized. Following the extensive database search, all eligible studies were exported to Endnote X9 library for screening. Title screening was done by the primary reviewer only (WPM). Abstract and full article screening was conducted by two reviewers (WPM and JvW) independently. The third screener was involved in resolving any discrepancies (JZP). We included studies written in any language.

Eligibility Criteria

Below are the eligibility criteria, which were developed to optimize our study selection process. The study research question guided these eligibility criteria

Inclusion criteria

Studies that met the following criteria were included:

- Focused on Obstructive Sleep Apnoea in adults
- Reported on surgical management of OSA in adults with a focus on UPPP and/or its variations
- Reported on the results of pre and post-operative polysomnography or a sleep study
- Published from January 2015 to December 2019

- Qualitative and quantitative studies, as well as abstracts from conference proceedings

Exclusion criteria

Studies were excluded if they had any of the following characteristics:

- They were conducted with children as participants
- Researched on patients with sleep-disordered breathing not meeting criteria for OSA
- Studies where the full-text article could not be obtained
- Studies reporting on weight loss surgery as part of the management of OSA
- Evidence from textbooks
- Literature reviews
- General reports

Quality appraisal

The Mixed Methods Appraisal Tool (MMAT) version 2018 was used as a quality appraisal method [52]. Section One was used for the appraisal of a qualitative study. Section Two was used for randomizing control. Section Three was used for nonrandomized. Lastly, Section Four was used for descriptive method studies. In mixed-method studies, Section One was used for appraisal of the qualitative component. Sections Two, Three, and Four were used for the quantitative component and Section Five for the mixed method component. The method used was adequate. Therefore, the study design, study selection, data collection, data analysis, presentation of findings, and author's discussion were useful for determining the study's conclusion. Inputs and scrutiny from all mentioned aspects determined the quality of the article produced. Independent reviewers, WPM and JZP, contributed by conducting the quality assessment. The percentage obtained in total from each included study was calculated and interpreted as follows:

- < 50% – low quality
- 50% to < 75% – average quality
- 75% to 100% – high quality

Charting the data

The data extraction sheet was developed and piloted before use. To demonstrate the critical aspects of the study, extractions came from the following domains: author and date; study title; study setting; sex and age of participants; sample size; intervention; outcomes measured; aim of the study; study design; relevant findings; significant findings; comments.

The data charting form was continually updated.

Collating, summarizing, and reporting the results

We provided a narrative account of the evidence revealed from the studies included. The data were analyzed using thematic content analysis. The review team analyzed the implications of data findings to check how they related to the research aims and objectives.

2.3 Results

2.3.1 Screening results

The literature searches and selection method is illustrated in Figure 2.1. A total number of 1981 articles were initially identified after title screening (Figure 2.1). We deleted duplicates, which resulted in the exclusion of 1673 articles. A total number of 89 abstracts were screened. Of these, 33 were selected for full article screening. Subsequently, 17 articles were excluded after the full article screening. Sixteen (16) of the 33 articles met the inclusion criteria and were included for data extraction. The reasons for this exclusion are as follows: twelve studies were literature reviews; three studies, full articles were not found; the last two studies to be excluded did not specify their outcome measures. Analysis of the full article screening results shows that there was 76.92% agreement versus 58.12% expected by chance, which constitutes a considerably poor agreement between screeners (Kappa statistic = 0.45 and p-value <0.05). However, McNemar's chi-square statistic suggests that there is no statistically significant difference in the proportions of yes/no answers by the reviewer with a p-value >0.05 (Appendix A). A third reviewer was appointed to resolve the discrepancies presented in full article screening results. The sample size of the studies included is illustrated in Figures 2.3 and 2.3.

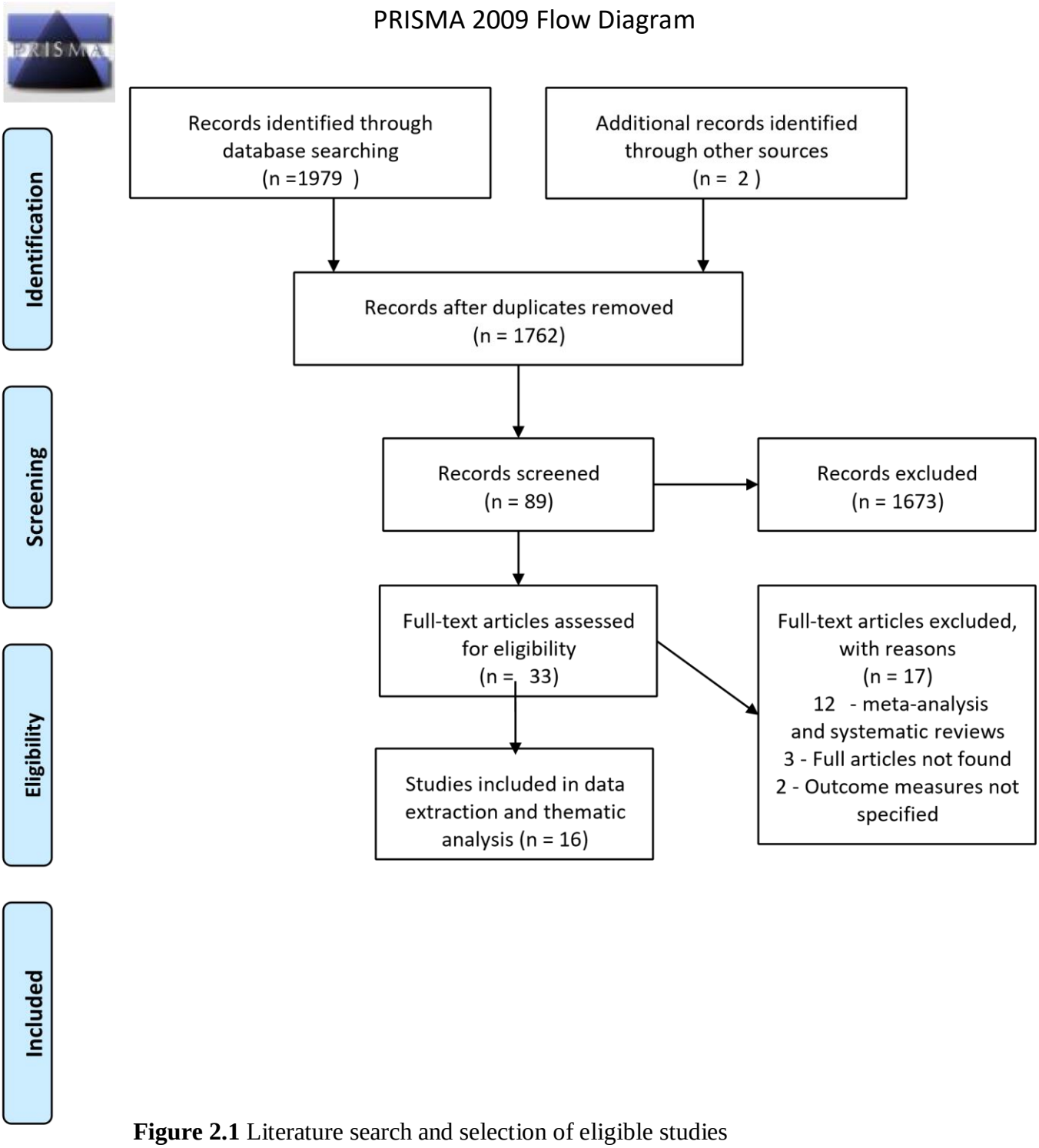

Figure 2.1 Literature search and selection of eligible studies

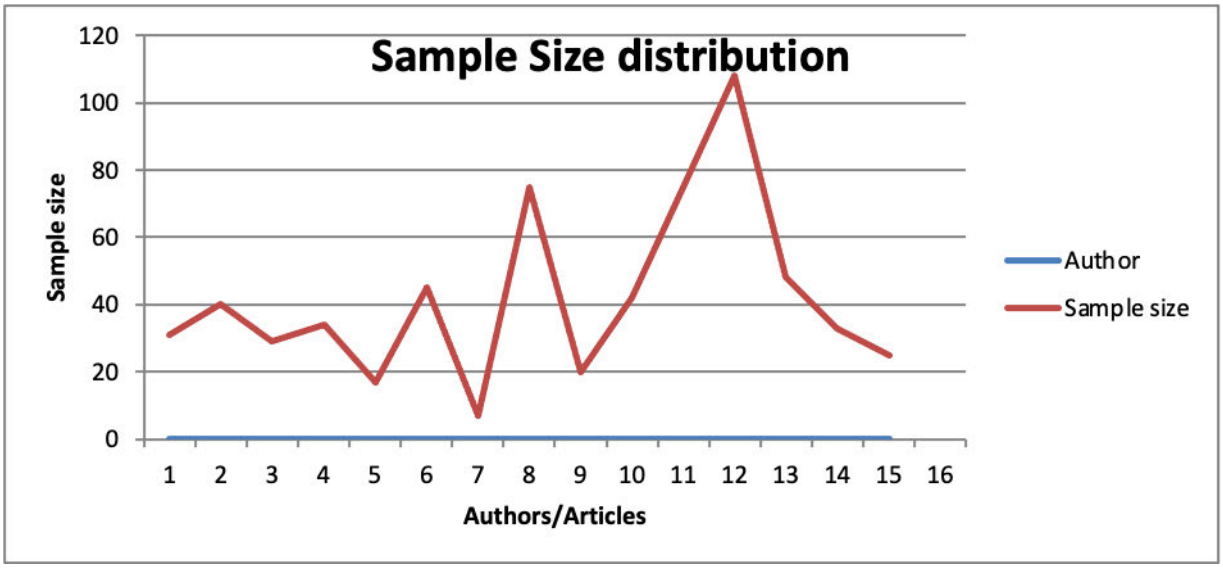

Fig 2.2 Sample Size Distribution of Selected Articles

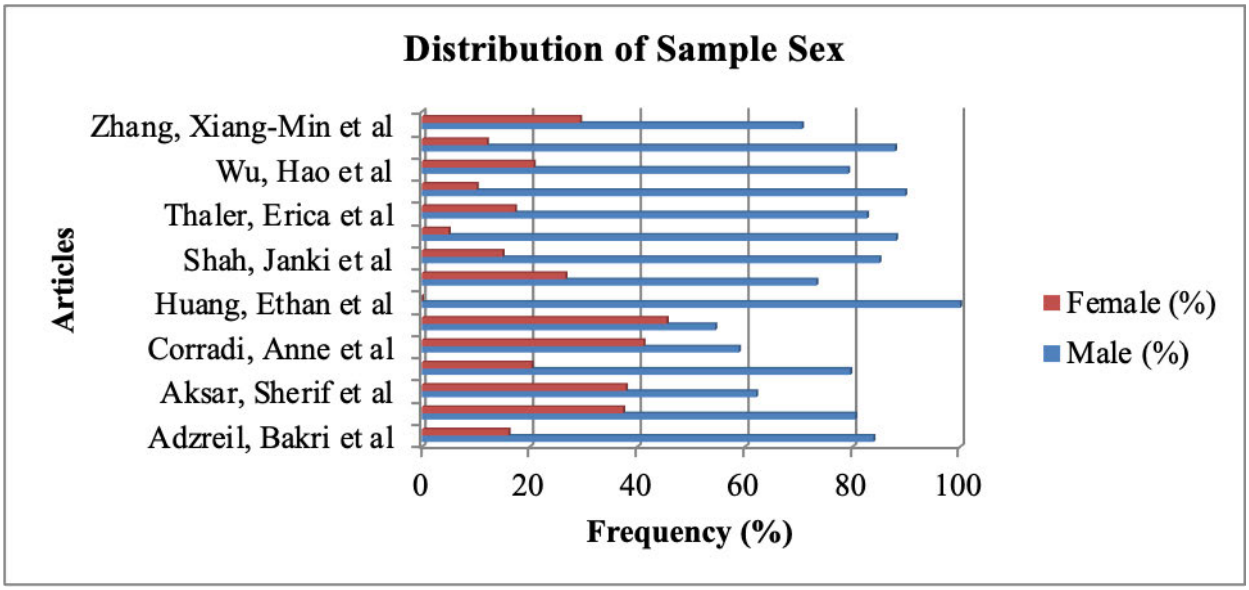

Fig 2.3 Sex Distribution of Study Participants

Characteristics of included studies

The characteristics of the studies included are presented in Table 2.2. Sixteen of the 33 reviewed articles were eligible for data extraction. Seventeen studies were excluded at the full article screening stage; twelve were systematic reviews and meta-analyses. On three of the studies, full articles could not be obtained, assistance from the librarian was sought, but full articles were still not obtained. The last two studies to be excluded at the full article stage did not specify the post-operative outcome measures. All of the studies were conducted in uppermiddle-income countries classified by the World Bank, June 2017 [53]. The settings for included studies were as follows: -United States of America [47,54]; Turkey [45]; Italy [55,56]; Germany [57,58]; China [59,60] Taiwan [55,61] Korea [62] Brazil [63] Egypt [64] Iran [65] and Malaysia [66]. Literature from lower-middle-income countries on the surgical management of OSA was not readily available.

All included studies were published between 2015 and 2019; only one study looked at UPPP alone [59]. It specifically looked at two types of pharyngeal closure techniques and found that the postoperative outcomes and complication rates were comparable [59]. Seven of the 17 studies compared UPPP to some of the newer surgical procedures for OSA. And the remainder of the studies looked at other surgical procures in the oropharynx, with the literature trends exploring more and more procedures targeting the base of the tongue or retro-lingual obstruction.

The total sample size in terms of human participants from the 17 included studies was 748. The majority of the studies had male participants, and this was consistent with the literature that estimates a male-to-female ratio of between 3:1 to 5:1. Fourteen studies looked at participants with BMI < 35. Marvisi, Maurizio, et al. and Chi, Jessie Chao-Yun, et al. looked at participants with a BMI up to 40kg/m2. Morbidly obese patients, BMI > 40kg/m^2 were excluded in all the studies, as this population of patients primarily need weight loss surgery before upper airway surgery for OSA.

Apnoea Hypopnoea Index was the single most consistently measured parameter in all the studies. And the average preoperative AHI score was 36.1 with an average post-op AHI score of 15.8, which was a statistically significant difference of $p<0.001$. Apnoea Hypopnoea Index is an important parameter to measure in OSA studies as a post-operative cure is defined as an improvement of greater than 50% of the preoperative AHI. Patients with severe AHI pre-operatively, and a 50% reduction of post-operative AHI may not yield enough post-operative improvement to qualify as a cure in these patient. The Epworth sleepiness score was assessed pre and post-operatively by 16 of the 17 studies. The average pre-operative ESS was 12.1, and the average postop ESS score was 6.8, which was also statistically significant $p<0.001$. The other parameters assessed in the included studies were Snoring visual analogue and O2 saturation, and their scores were not statistically significant. One of the drawbacks of UPPP has been the postoperative difficulty in swallowing. A study by Corradi, Anne MB, *et al.* [63] looked specifically at the post-operative swallowing outcomes that compared UPPP and Expansion Pharyngoplasty. Their findings were that both surgical procedures led to an increased hyoid movement time and an increased frequency of laryngeal penetration in the early postoperative period during liquid ingestion. For pasty consistency, both techniques reduced velum movement time and increased pharyngeal transit time and stasis rate in the hypopharynx. All these parameters reached or tended to reach the pre-operative indices at postoperative day 28.

Table 2.2 Characteristics of included studies

Table 1: Study characteristics

Author and Date	Population/ Patient Group	Sex	Age	Sample Size	Country	Aim	Surgical Procedure	Significant Findings	Conclusion	Study Design
Adzreil, B. 2017	Inclusion: >18 year,BMI<35 snoring with AHI<5,AHI>5,Freidman tongue position I,IIa,IIB, retropalatal obstruction with minimal tongue base collapse. Exclusion:BMI>35,upper airway obstruction other than retropalatal or tonsil hypertrophy, other sleep disorder,	26 (83.9%) Male, 5 (16.1%) Female	Mean 36.8	31 (6 mild,13 moderate,12severe OSA)	Malaysia	Investigate the effectiveness of tonsillectomy and anterior palatoplasty in the treatment of snore and OSA	Combined tonsillectomy and anterior palatoplasty	ESS: Pre-op: 13.3 +/- 4.5 (3-22), Post-op 3 months: 6.3 +/- 3.7 (2-15) p<0.001, Post-op 1 year: 7.1 +/- 4.5 (1-18) p<0.001 AHI: 35 +/- 23.9 (3-101), Post-op 3 months: 16.6 +/- 17.3 (2-78) p< 0.001, 18.5 +/- 16.3 (4-80) p<0001 Surgically Successful AHI (AHI decrease by >50%, AHI <10): Post-op 3 months: 45.2% (n=14), Post-op 1 year: 32.3% (n=10)	Tonsillectomy and anterior palatoplasy is an option in mild to moderate OSA with retropalatal obstruction	Non-randomized Quantitative Study
Amali, A. 2017	40 Patients with mild to moderate OSA Inclusion: Age >18, 5<AHI <30, velopharyngeal or oropharyngeal lateral walls obstruction, no prior treatment, BMI<35kg/m^2.	41 (33 M; 8 F)	Mean 37.4	40 patients with mild to moderate OSA	Iran	To compare the efficacy of modified radiofrequency tissue ablation (MRFTA) with uvulopalatopharyngoplasty (UPPP) based on both subjective and objective outcome measures in patients with mild to moderate obstructive OSA	Modified radiofrequency tissue ablation + UPPP	Fourteen of 19 patients (73%) in the UPPP group and 8 of 20 patients (40%) in the MRFTA group met the predefined success criteria	This study suggested that for mild OSA, the efficacy of MRFTA in lowering AHI was comparable to the efficacy of UPPP. MRFTA proved to be more effective than UPPP to enhance quality of life of patients because of less morbidity and fewer treatment-related symptoms.	Randomized clinical trial
Askar, S. M. 2018	**Inclusion**: AHI > 15 and BMI < 35 kg/m2. Predominant retro-palatal collapse (without other levels). **Exclusion**: BMI ≥ 35 kg/m2 , macroglossia, and the presence of multilevel upper airway obstruction (e.g., nasal polyps, hypertrophic inferior turbinates, adenoid hypertrophy, and retrolingual collapse). Patients with history of surgical intervention for snoring/ OSA (e.g., UPPP) or for neck pathology were excluded.	29 (18 M; 11 F)	Mean 37.3	29 patients with OSA, noncompliant with CPAP	Egypt	To investigate the outcome of combined two simple techniques: modified anterior palatoplasty (MAP) and DSS (with or without tonsillectomy) for the treatment of OSA	Modified anterior palatoplasty and double suspension sutures (with or without tonsillectomy)	Mean AHI dropped significantly (p < 0.0001, t = 17.5024) from a mean of 28.6 ± 5.5 preoperatively to 8.3 ± 2.96 postoperatively. Successful outcome was reported in 26 patients (98.65%) while 3 patients (10.35%) were non responders	Combined MAP and DSS could be considered as simple, easily trained, reliable, effective, and safe surgical treatment option for OSA patients with predominant retropalatal obstruction	Prospective Quantitative study

Author and Date	Population/ Patient Group	Sex	Age	Sample Size	Country	Aim	Surgical Procedure	Significant Findings	Conclusion	Study Design
Corradi, A.M.B. 2018	**Inclusion**: Age 20 to 50 years, and with BMI <35 kg/m2 , as both age and obesity could influence swallowing patterns. **Exclusion**: Friedman III or IV, with neurological disorders, genetic syndromes, and patients who have already undergone previous surgical treatment for OSAS.	17 (10 M; 7 F)	Mean 37	17 patients, UPPP group 10 participants (6 male and 4 female) with mean age 36.3±7.7 years. EP group 7 participants (4 male and 3 female) with mean age 37.0±8.7 years.	Brazil	To evaluate the effect of pharyngeal surgery on swallowing pattern in patients with obstructive sleep apnea syndrome (OSAS), and to compare two surgical techniques: uvulopalatopharyngoplasty (UPPP) and expansion pharyngoplasty (EP), through videofluoroscopy.	UPPP vs. expansion pharyngoplasty	There was no statistically significant difference between surgeries regarding any analyzed parameter for liquid ingestion. For pasty consistency, patients who underwent EP presented significantly higher pharyngeal constriction time (P < 0.05) than those submitted to UPPP at T3.	OSAS patients already show, before surgery, sub-clinical changes in swallowing pattern. Both UPPP and EP techniques are related to transitory changes in swallowing biomechanics. Recovery to pre-operative levels occurs, in general, 1 month after surgery.	Longitudinal prospective cohort
Haytoglu, S. 2018	**Inclusion**: apnea-hypopnea index (AHI) of greater than 5 and less than 30, a body mass index (BMI) of less than 30 kg/m^2 a tonsillar hypertrophy grade of 0 or 1 and the presence of retropalatal obstruction. **Exclusion**: previous palatal surgery, the presence of retrolingual obstruction, and the presence of a chronic disease that prevented surgery.	Not specified	Not specified	50 patients 25 were randomly assigned to undergo anterior palatoplasty and 25 were randomized to uvulopalatal flap surgery. Tonsillectomy was not performed in either group.	Turkey	To compare the efficacy of anterior palatoplasty and the uvulopalatal flapproceduresfor the treatmentofmildandmoderate OSASin patientswith retropalatalobstructionwhodid not require a tonsillectomy.	Anterior palatoplasty and uvulopalatal flap placement	The mean AHI in the palatoplasty group improved significantly from 17.5 before surgery to 8.1 at 6months postoperatively(p<0.001).In the flap group, the AHI fell from 18. The VAS score for snoring was 8.1 preoperatively and 3.0 postoperatively (p < 0.001) in the palatoplasty group and 8.6and 2.8, respectively, in the 5 to 8.6 (p <0.001). There were no significant differences between the two groups either pre- or postoperatively.	The study found that anterior palatoplasty and uvulopalatal flap placement were equally effective in the treatment of patients with mild and moderate OSAS secondary to retropalatal obstruction. Recommend anterior palatoplasty because it is associated with less postoperative pain.	Randomized Control Trial
Huang, E. I. 2018	**Inclusion**: Age> 20 years, unsuccessful or refusal of CPAP, AHI > 30 events/h, BMI < 35 kg/m2 Received a one-stage multi-level sleep surgery with the modified ZPP performed with one-layer closure	7 M	Between 25 and 52	7 male patients with severe OSA	Taiwan	To evaluate the surgical outcome of modified ZPP with one-layer closure, as an element of one-stage multilevel surgery for severe OSA patients, by apnea–hypopnea index (AHI)	Modified Z-palatoplasty with one-layer closure	The mean and standard deviation of AHI before the surgery was 52.9 events/h and decreased to 18.4 after the surgery	Our results suggest that the one-layer closure remains efficacy of modified Z-palatoplasty with two-layer closure in one-stage multilevel surgery for severe obstructive sleep apnea	Non Randomized Prospective study

Author and Date	Population/ Patient Group	Sex	Age	Sample Size	Country	Aim	Surgical Procedure	Significant Findings	Conclusion	Study Design
Shah, J. 2018	**Inclusion**: moderate to severe OSA (AHI between 20 and 65), inability to adhere to CPAP therapy, body mass index (BMI) ≤32 kg/m2 , and absence of complete circumferential oropharyngeal collapse on drug-induced sleep endoscopy (DISE).	20 (13 M; 7 F)	Mean 42 UPPP group, 62 HNS group		USA	To compare outcomes in patients who underwent traditional upper airway surgery, particularly UPPP, to those who underwent HNS therapy for moderate to severe OSA and to evaluate the efficacy of each method in successfully treating OSA.	Uvulopalatopharyngoplasty vs CN XII stimulation	For patients who underwent HNS, mean preoperative BMI was 28.0. Mean AHI decreased significantly from 38.9 ± 12.5 to 4.5 ± 4.8. All patients achieved an AHI < 20 post implant with 65% (13/20) with an AHI ≤ 5. For patients who underwent traditional airway surgery, mean preoperative BMI was 27.5; mean AHI decreased from 40.3 ± 12.4 to 28.8 ± 25.4.	While both traditional surgery and HNS are effective treatments for patients with moderate to severe OSA with CPAP intolerance, our study demonstrates that HNS is "curative" in normalizing the AHI to < 5 in the majority of patients.	Retrospective case series
Sommer, J Ulrich 2016	**Inclusion:** AHI >15, CPAP intolerance, and tonsillar hypertrophy with velopharyngeal obstruction **Exclusion:** <18 years, > 65 years, BMI >34 kg/m²	Total: 37 male (88.1%), 5 female (11.9%); Treatment Group: 23 male (100%), 0 female (0%); Control Group: 8 male (42.1%), 11 female (57.9%)	Total: 37.4 +/- 10.7; Treatment Group: 36.6 +/- 12.5; Control Group: 38.4 +/- 8.5	20 patients underwent HNS implantation between November 2015 and November 2016. Of the 20 patients, 65% (13/20) were male and 35% (7/13) were female. Mean age was 62.4 ± 8.9 years. Mean BMI was 28.0 ± 2.1 kg/m2. Thirty five percent (7/20) of patients had undergone previous upper airway surgery for OSA including UPPP (3/20), septoplasty and inferior turbinate reduction (3/ 20) and mandibular advancement (1/20).	Germany	To conduct a randomized controlled trial on the efficacy and safety of TE-UPPP as a treatment for obstructive sleep apnea.	Tonsillectomy with Uvulopalatopharyngoplasty	42 patents were included in the trial (23 in the treatment group, 19 in the control group). The baseline AHI was 35.7 ± 19.4/hr in the control group and 33.7 ± 14.6/hr in the treatment group. At 3 months these were 28.6 ± 19.4/hr in the control group and 15.4 ± 14.1/hr in the treatment group (p = 0.036).	TE-UPPP significantly improved apnea/hypopnea, daytime sleepiness, and snoring compared to control (i.e., no) treatment. It is a safe and effective treatment for OSA.	Two Center Randomised Control Trial

Author and Date	Population/ Patient Group	Sex	Age	Sample Size	Country	Aim	Surgical Procedure	Significant Findings	Conclusion	Study Design
Marvisi, Maurizio 2015	**Inclusion:** apnoea–hypopnoea index (AHI)[10/h and excessive daytime sleepiness [Epworth sleepiness scale (ESS) C 10 points] and no previous treatment for OSA. **Exclusion:** obstructive or restrictive lung disease demonstrated on pulmonary function testing; left ventricular ejection fraction (EF)\45 %, ischaemic or valvular heart disease; connective tissue, thyroid diseases and chronic thromboembolic disease; history of cocaine or appetite suppressant drug use and morbid obesity (body mass index [40 Kg/m2].	95(75 OSA; 20 Healthy)	Mean 55	75 patients with OSA(from 2007 to 2012) (group 1) and 20 healthy subjects (group 2) as a control group	Italy	To assess the prevalence of PH in OSA patients without pulmonary and cardiac diseases and to evaluate the efficacy of CPAP and UPPP in normalizing PH and some parameters of Metabolic Syndrome(MS).	UPPP vs CPAP	A substantial proportion (33 %) of patients with OSA and without any other primary lung and cardiac disease exhibits mild daytime PH at rest; (2) the emergence of PH seems to be related to male sex, older age, high BMI, high NC and serum concentration of uric acid (UA) and (3) treatment with CPAP and UPPP resulted in a normalization of PAPS after only 3 months of treatment.	In conclusion, our study confirms the high prevalence of PH in OSA patients (33 %). Risk factors for the development of PH are: male sex, older age, higher BMI and NC, UA concentration in serum. Both CPAP and UPPP reduce PAPs, which in this study normalized after 3 months	Non Randomised Control Trial
Park, D. Y. 2018	Not specified	65 adult patients with OSA	Not specified	Retrospective review of patient records from 2013 to 2015. Among the patients with OSA, our OLP technique was applied to 65 patients who declined or failed to adhere to CPAP treatment. And 29 patients agreed to postoperative PSG. Study patients received OLP alone or OLP combined with CobTBR. The patients were classified into two groups.	Korea	To introduce the overlapping LP (OLP) technique and analyze the surgical outcomes of OLP alone and OLP combined with coblator tongue base resection (CobTBR)	Overlapping lateral pharyngoplasty with or without coblator tongue base resection	In the OLP group, 91.7% of patients showed a surgical response and the overall success rate was 66.7%. Mean AHI improved significantly from 36.3 to 14.8. In the OLP+CobTBR group, all patients showed improvement in AHI and the surgical response rate was 100%. The overall success rate was 70.6% and mean AHI improved from 38.8 to 13.1.	Our OLP technique appears to be safe and effective among OSA patients. Multi-level OLP surgery combined with CobTBR can be a good surgical strategy for patients experiencing retroglossal obstruction.	Retrospective chart review

Author and Date	Population/ Patient Group	Sex	Age	Sample Size	Country	Aim	Surgical Procedure	Significant Findings	Conclusion	Study Design
Thaler, E. R. 2016	**Inclusion:** >18 yrs, failed prior CPAP, AHI > 20 **Exclusion:** Not defined	75 (62 M;13 F)	62 years male (82.7%), 13 female (17,3%)	75	USA	To evaluate the outcomes of multilevel surgery for patients with OSA who underwent transoral robotic surgery (TORS) (i.e., posterior glossectomy and limited lateral pharyngectomy) with UPPP.	Transoral robotic surgery (TORS) (i.e., posterior glossectomy and limited lateral pharyngectomy) + UPPP.	Patients who had no prior surgery achieved an average AHI reduction from 58.4 to 19.5 a surgical success rate of 56%, and a surgical response rate of 73%. Patients with prior pharyngeal surgery achieved an AHI reduction from 55.0 to 45 (24%, P 5.19), a surgical success rate of 30%, and a surgical response rate of 40%.	Outcomes for the combined approach of OSA TORS and UPPP provide strong evidence in favor of this multilevel approach for the surgical management of OSA. The benefit of the current surgical approach is most significant for previously unoperated patients.	Prospective, nonrandomized trial with historical controls
Verse, Thomas 2015	**Inclusion:** AHI >15 and combined palatal and retrolingual obstruction **Exclusion:** Not documented	97 male, 11 female	mean +/- SD 49.1 +/- 10.2 years	108	Germany	To compare results in patients with obstructive sleep apnea (OSA) undergoing multilevel surgery with two different surgical approaches to treat tongue base obstruction	Lingual tonsillectomy vs. hyoid suspension in combination with radiofrequency of the tongue base + UPPP	In group A, the mean AHI decreased by 49.7 %, and in group B by 48.3 %. Patients with simultaneous tonsillectomies showed significant better results as compared to patients after prior tonsillectomies (success rate 76.6 vs. 27.3 %).	Simultaneous tonsillectomy has a significant impact on objective results of multi-level surgery (MLS). Study results should be adjusted for this parameter. Having done this, MLS with LT seems to produce superior results as compared to HS+RFTB.	Prospective Controlled clinical Trial
Vicini, C. 2017	**Inclusion:** Underwent robotic barbed reposition pharyngoplasty, complete a one year follow-up full overnight sleep study **Exclusion:** Not documented	Not documented	64 years, range 45-74	10	Italy	To describe the technique of Barbed reposition pharyngoplasty in multilevel robotic surgery and present preliminary results	Barbed reposition pharyngoplasty in multilevel robotic surgery		Barbed reposition pharyngoplasty in multilevel robotic surgery for OSA may represent a valid option to surgically approach the soft palate.	Prospective Quantitative study

Author and Date	Population/ Patient Group	Sex	Age	Sample Size	Country	Aim	Surgical Procedure	Significant Findings	Conclusion	Study Design
Wu, Hao 2016	**Inclusion:** Loud snoring, sleep apnea, daytime sleepiness, or arousal from sleep AND OSA by polysomnography AND thickened or elongated soft palate AND objective evidence of obstruction in the palatopharyngeal plane AND refusal of CPAP or history or failed treatment **Exclusion:** Nasal cavity obstruction, BMI >40 kg/m², prior surgical intervention for OSA, hypertrophy of the tongue or lateral pharyngeal band, mandibular retrognathism	38 (79.2%) male, 10 (20.8%) female	Group 1: median 44 years, range 26-66 years Group 2: median 4 years, range 29-60 years	48 patients, Group 1 – 24, Group 2 - 24	China	To compare the outcomes of two different methods of pharyngeal cavity reconstruction in UPPP.	UPPP with two methods of pharyngeal cavity reconstruction	No significant difference was observed in surgical success (p ¼ 0.54), subjective syndromes (snoring, sleep apnoea, morning headache, daytime sleepiness) (p ¼ 0.16, 0.36, 0.79 and 0.52), ESS (p ¼ 0.41), apnoea-hypopnoea index (AHI) (p ¼ 0.32), and minimum SaO2 (p ¼ 0.13) between the two groups.	The efficacy of UPPP can be achieved without application of an apposition suture of the palatopharyngeal arch and the palatoglossal arch.	Prospectiv e Mixed Methods Study
Zhang, X. M. 2015	**Inclusion:** Stenosis mainly in the velopharyngeal plane, patients could not tolerate or would not use CPAP. **Exclusion:** Medical or surgical contraindications, main stenosis not in the velopharyngeal plane, stenosis due mainly to hypertrophy or flabbiness of the tongue, mandibular retrusion,	12 (70.6%) males, 5 (29.4%) females	Median: 47.0 years (Interquartile Range 40.5-54.0	25 (2 moderate, 23 severe)	China	To explore a new type of soft palatal surgery for the treatment of adult OSAHS, and describe the subjective and objective results of this new surgery combined with UPPP and inferior turbinate radiofrequency, and assess its safety and feasibility.	Novel palatal implant and support surgery with tonsillectomy, palatopharyngeal arch release, partial uvula resection, and inferior turbinate radiofrequency ablation as needed as part of a modified UPPP	The median AHI was 16.0 at 6 months and 20.9 at 12 months after the operation. The pre-operative median LSaO2, 74.0, was significantly increased to 82 at 6 months and 80 at 12 months after the operation. VAS was significantly decreased from the pre-operative median of 8.0 to 3.0 and 3.0 at 6 and 12 months after the operation, respectively. ESS was significantly decreased.	Soft palate surgery is less invasive, has mild postoperative reaction, good graft safety, and results in good short-term efficacy in patients with moderate to severe OSAHS and velopharyngeal obstruction.	Pilot Study

2.4 Study findings

Through thematic analysis, the following trends emerged on the current evidence for the surgical management of OSA in adults.

2.4.1 Role of upper airway surgery in OSA

Alternative treatment options for select patients unable to tolerate CPAP include oral appliance therapy, positional therapy; weight loss; and upper airway reconstructive surgery. Oral appliance therapy is not a long-term management solution. Surgery is considered second-line treatment. However, as this study has shown, no one surgical solution is suitable for all patients with OSA. As a historical procedure for OSA, Uvulopalatopharyngoplasty has undergone modifications aimed at reducing morbidity over the years. However, the postoperative outcomes with regards to objective success have remained similar. And also, the absolute indications for surgery are not clearly defined in the literature, and therefore further research is needed to address this gab.

2.4.2 Base of tongue targeted procedures

Historically, OSA procedures have focused on addressing the soft palate, lateral pharyngeal wall +/- palatine tonsillectomy. This study identified the theme of alternative procedures targeting the base of the tongue, i.e., modified radiofrequency ablation of the base of tongue tissue; transoral robotic surgery posterior glossectomy; hypoglossal nerve stimulation; and et cetera, to have increasingly become an area of interest in the past five years. Studies to evaluate the quality of life outcomes, specifically swallowing and evaluation for any aspiration symptoms postoperatively in patients who have undergone base of tongue surgery is an area of research that needs to be studied further.

2.4.3 Pre-operative workup and surgical planning

The main challenges that the surgeon faces in OSA management are patient selection and choice of procedure. A third theme identified that seeks to address this is that of multi-level surgery and pre-operative workup aimed at identifying the anatomical level of obstruction. Two of the included studies that examined multi-level surgery's theme included UPPP as part of the surgery and reported favorable outcomes. This approach depended on the ability to preoperatively assess the obstruction level by way of drug-induced sleep endoscopy plus dynamic neck MRI. In resource-limited settings, these investigations may not be readily available. Therefore, more research is needed to look at alternative investigations that can be done in LMIC's with limited resources that can enable the provision of an adequate preoperative workup for these patients.

2.4.4 Role of polysomnography

Sleep study remains a vital part of the diagnostic workup of OSA patients. In the surgical setting, it provides valuable information to evaluate objective outcomes post-operatively. However, the literature shows that with regards to surgical workup specifically, investigations that can assess the anatomical level of obstruction, i.e., DISE and dynamic neck MRI have become more valuable. However, as cited above, these investigations may not always be readily accessible**.**

2.5 Discussion

The theme of oropharyngeal surgery as an alternative in patients that fail to adhere to first-line CPAP therapy is well documented in the literature. Park et al. (2017) reported a study that evaluated factors influencing CPAP adherence and anatomic characteristics of the upper airway in OSA subjects. Their study found that excessive upper airway blockage in the nasal cavity and oropharynx was predominant in CPAP no adherent subjects, which might cause the reported subjective discomfort that reduces CPAP compliance. Therefore, the resolution of these issues through multi-level surgery is needed to enhance CPAP compliance for control of OSA [62].

Vicini et al. (2011) reported on a study that evaluated the efficacy of transoral robotic surgery of the base of the tongue. Having evaluated twenty patients with a median follow-up period of 10 months, their study found that trans oral robotic surgery (TORS) for the tongue base was feasible, with no major complications and satisfaction of the majority of patients. Mean apnoea hypopnea index (AHI) improvement was 24.6, mean Epworth Sleepiness Scale (ESS) improvement was 5.9 [56]. The study evaluated the procedure as being safe, easy to learn, and associated with complications of minimal significance. However, a larger experience, possibly not limited to a few centres and may be included in controlled trials, with longer-term followup

will tell us the real utility of this surgical procedure for the future. Hypoglossal nerve stimulation is one of the tongue base targeted surgical procedures that has shown positive outcomes in the literature.

In 2011, Eastwood et al. evaluated twenty-one patients with moderate to severe OSA with an objective to examine the safety and efficacy of a novel Hypoglossal Nerve Stimulation (HGNS) system (HGNS, Apnex Medical, Inc.) in treating OSA [67]. The primary efficacy endpoints were the mean change in AHI and Functional Outcomes of Sleep Questionnaire (FOSQ) total score at 3 and 6 months post-implant compared to baseline. Even though this study reported significant objective and subjective improvements, some of the drawbacks were the limited number of participants, no control group, and only six months follow-up. Hypoglossal nerve as a procedure was noted to have some limiting factors, the direct effect of HGNS is tongue protrusion; its therapeutic effect is dependent on predominant retro lingual obstruction or, in the case of predominant velopharyngeal obstruction or multisite obstruction, good coupling between tongue displacement and the velopharyngeal airway via the fauces and tissues of the soft palate. Patients who have very crowded airways with obstruction at multiple levels may not receive as much benefit from this approach. However, this also supports the theme of the multilevel approach as combining HGNS with upper airway procedures that target other sites of obstruction may improve the overall results.

Huntley *et al*. (2017) retrospectively reviewed patients undergoing surgery for OSA. They compared those patients undergoing preoperative DISE to those who did not, to assess the surgical procedures performed and their outcomes [67]. During the DISE procedure, the patient is sedated with propofol, and a modification of the VOTE classification is used to assess the site, pattern, and severity of collapse [68]. After an appropriate plane of anaesthesia is achieved, a flexible fiberoptic bronchoscope is passed through the nose, and the velum, oropharynx, base of the tongue, and epiglottis are evaluated. The site of upper airway collapse found during DISE was then addressed surgically [69]. Their study concluded that DISE allowed localization of upper airway obstruction sites, improved surgical planning, elimination of unnecessary procedures, and improved surgical outcomes. Further studies with larger cohorts in a prospective manner are needed to collaborate these findings.

2.5.1 Strengths and limitations of the study

An intensive and exhaustive search was conducted to identify the relevant studies to answer our research question. To increase the chances of finding eligible studies, the Boolean terms and MeSH were used during the database search. Screening and data extraction tools were piloted to improve the reliability of the study. The study had robust reliability, which was supported by measuring the degree of agreement between different study results to rule out any

bias. We also assessed the quality of the studies included by utilizing the MMAT. One of the limitations of this study is that the differences in patient inclusion and exclusion criteria varied between the included studies. The severity of OSA was also quite different. Also, many of the included studies were relatively small in terms of patient recruitment, which limits the power of the conclusions drawn in them. However, this may be explained by the low prevalence of OSA in the general population. Despite these limitations, this study was able to map current evidence for the surgical management of OSA by way of oropharyngeal surgery and the variations to UPPP.

2.5.2 Recommendations for future research

Surgical management of OSA remains an area of much debate and differing opinions amongst otorhinolaryngologists. Many of the included studies had a limited number of participants, and only two were randomized control trials. This presents a methodological gap in the literature. Additional studies are needed to look at the development of preoperative workup protocols in LMIC's, including sub-Saharan Africa, that may not have facilities for drug-induced sleep endoscopy and dynamic neck MRI readily available. We would also recommend more studies to look at the long-term quality of life outcomes of the newer oropharyngeal procedures for OSA, i.e., transoral robotic surgery, modified radiofrequency tongue base tissue ablation, hypoglossal nerve stimulation, etc.

2.5.3 Implications for practise

Evidence from this scoping review indicates that oropharyngeal surgery is a viable option for managing OSA in patients who fail CPAP use. Pre-operative sleep endoscopy is indicated to document the preoperative AHI for comparative purposes with postoperative outcomes. Management of OSA in adults requires a multidisciplinary approach with a team that includes dieticians, psychologists (psychosocial support, behavioral changes, and weight loss), neurologist's/sleep physicians (sleep studies, DISE, and to rule out neurological aetiological factors), and otorhinolaryngologists for the surgical planning. Multi-level surgery, which includes a procure targeting the soft palate and one that targets the base of the tongue, is recommended for the management of these patients. However, a surgical plan needs to be developed for each patient individually, depending on the preoperative investigation findings. Long-term follow-up and assessment of the quality of life outcomes is also essential to document.

2.6 Conclusion

UPPP was found to have undergone multiple variations over the past 5years; however, it remains effective, especially as part of a multi-level surgical approach in OSA management. Procedures targeting the base of tongue obstruction show promising results, but high-powered

clinical trials are needed to collaborate the post-surgical outcomes reported in the literature. This review also found that pre and post-operative polysomnography remains essential to evaluate the objective outcomes; however, investigations aimed at identifying the anatomical level of obstruction are more valuable as part of the surgical planning process.

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Availability of data and materials

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Authors contributions

The study has been conceptualized and designed by WPM, JVW and TPM-T. The initial draft and protocol of the study has been prepared by WPM under JVW's supervision. WPM and JVW contributed to the abstract and full article screening, with JZP assisting to resolve any disagreements. The draft was critically reviewed by all authors. All authors approved the final version of the manuscript.

Ethics approval and consent to participate Not applicable.

The were no human participants.

Consent for publication

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CHAPTER 3: STUDY SYNTHESIS, RESULTS, AND DISCUSSIONS

3.1 Introduction

This chapter lays out the summary of the main findings and presents the study's limitations and strengths. Furthermore, it provides the link between the findings and aims and the objectives of this research study. Recommendations are suggested for future research and clinical practice, based on the main findings.

3.2 Main research question

The aim of the current study was to map global literature on the surgical management of Obstructive Sleep Apnoea in adults, with a focus on uvulopalatopharyngoplasty. The main research question was "What is the current evidence on the use of UPPP as a stand-alone procedure or in combination with other oropharyngeal procedures for the management of OSA in adults?".

In the literature, there is evidence that in the surgical management of OSA in adults, UPPP is more effective when it is performed with other procedures, as opposed to being performed as a standalone procedure. There were two studies reviewed in the current study that reported notable results in this regard. These studies looked at UPPP as part of a multilevel surgical approach for OSA. Thaler *et al.,* in a prospective non-randomized trial with a historical cohort, reported on the outcomes of transoral robotic surgery (i.e., posterior glossectomy and limited lateral pharyngectomy) plus UPPP [47]. They concluded that the outcomes of the multilevel combined approach were more favorable than those of UPPP alone. However, they made emphasis on the extensive preoperative workup of patients; in this study, the preoperative workup included polysomnography, MRI of the neck, and drug-induced sleep endoscopy. As literature has shown that techniques such as dynamic magnetic resonance imaging (MRI) and drug-induced sleep endoscopy (DISE), in particular, are essential in establishing the anatomic level of obstruction in OSA, which enables a targeted multi-level surgical approach.

Verse *et al*. also examined the subject of UPPP as part of a multi-level surgical approach [58]. They looked at a cohort of 108 participants that underwent lingual tonsillectomy + radiofrequency of tongue base + UPPP (group A) or hyoid suspension + radiofrequency of tongue base + UPPP (group B). They found that group A postoperative AHI was superior to those of group B and that simultaneous tonsillectomy had a significant impact on objective results of multi-level surgery. The study did not report on subjective outcomes. These two studies noted that UPPP, in its historical form, is more effective as part of a multilevel approach rather than in isolation as it only targets one level of obstruction.

3.2.1 The research sub-questions are as follows:

- What variations of UPPP have been developed in the past five years.

The reviewed literature from the past five years revealed that UPPP remains an integral part of the management of OSA in adults. However, there is a trend to combine some elements of the procedure with less invasive methods. This study also noted a trend towards multilevel surgery that includes some parts of UPPP. Askar et al. looked at modified anterior palatoplasty plus double suspension sutures with/without tonsillectomy and found it an effective procedure in patients with predominantly retro palatal obstruction [64]. Haytoğlu *et al*. looked at a subset of patients with mild-moderate OSA and used a variation of UPPP that only included an anterior palatoplasty and a uvulopalatal flap placement [61]. This also proved to be effective in patients with retro palatal obstruction. They also noted less postoperative pain with the procedure. In a two-center randomized control trial, Sommer et al. (2016) looked at 42 patients, with 23 in the treatment group undergoing UPPP plus tonsillectomy and 19 patients in the control arm receiving no treatment. They found that performing a tonsillectomy with UPPP significantly improved the overall postoperative outcomes (AHI, daytime sleepiness, snoring scores, etc.). Other variations that were noted include the introduction of robotic pharyngeal surgery [56], different methods of pharyngeal reconstruction post-UPPP [59], palatal implant, and support surgery with tonsillectomy pharyngeal arch release, partial uvula resection [60].

- Are the post-operative outcomes of UPPP and/or its variations comparable to those of other oropharyngeal procedures for OSA?

Yes, a few of the included studies looked at the postoperative outcomes of the variations of UPPP. They found that their post-operative outcomes were comparable to those of other oropharyngeal procedures. Amali et al. (2017) reported on the outcomes of UPPP compared with modified radiofrequency tongue base tissue ablation based on both the subjective and objective outcome measures in patients with mild to moderate OSA [65]. They reported that the efficacy of MRTA in lowering AHI was comparable to UPPP. However, patients who underwent MRTA reported better overall quality of life improvement with less morbidity and fewer treatment-related symptoms on the subjective outcomes. One of UPPP's significant criticisms in the literature is postoperative swallowing difficulties, with some patients reporting aspiration and a globus sensation. Corradi *et al*. (2018) looked at the post-operative swallowing outcomes of pharyngeal surgery, i.e., UPPP vs. Expansion Pharyngoplasty (EP) through videofluoroscopy [63]. They found that there was no statistically significant difference between surgeries regarding liquid ingestion. Both UPPP and EP are related to transitory changes in swallowing biomechanics, but these generally recover to preoperative levels within 1month post-surgery. Shah *et al*. reported on a retrospective cohort of patients that had

undergone UPPP and compared their outcomes to those patients that had undergone a relatively new procedure of Hypoglossal Nerve Stimulation (HNS) [54]. They concluded that while both traditional surgery and hypoglossal nerve stimulation are an effective treatment for patients with moderate to severe OSA with CPAP intolerance, their study demonstrated that HNS is curative in normalizing AHI to < 5 in the majority of patients.

- Is preoperative polysomnography done in all patients before oropharyngeal surgery for OSA?

For diagnostic purposes, polysomnography is the gold standard in adult patients suspected of having OSA. However, once the diagnosis of OSA has been made, polysomnography is not indicated as a part of the preoperative workup. For comparative purposes, a post-operative polysomnogram is a valuable tool. Additionally, this study found that investigations aimed at identifying the anatomical level of obstruction are of paramount importance. These include dynamic MRI of the neck and drug-induced sleep endoscopy. Based on the findings of these studies, uni-level or multilevel surgical approach can be planned for single-level or multi-level obstruction, respectively.

3.3 Discussion

The surgical success rate for OSA is variable, likely because OSA is a complex disorder; it is a heterogeneous syndrome that can have many causes and factors contributing to it at the same time. Differing levels of obstruction, patient characteristics (such as body mass index and age) play an essential role in defining which type of surgery to perform. Our study showed that multiple variations of UPPP have been developed over the past few years, and in appropriately selected patients, upper airway surgery can improve the patient's symptoms, as shown by the differences in the pre and postoperative AHI levels. Our findings also indicate that no one surgical procedure can be used indiscriminately to treat all patients. Therefore tailoring each surgical management plan to each individual patient's particular problem based on the level of obstruction is of paramount importance.

While positive airway pressure remains the first-line therapy for moderate to severe OSA management, its effectiveness is limited in many patients due to poor long-term compliance rates. Left untreated, these patients are at increased risk for cardiovascular disease and neurocognitive dysfunction. Given the increased morbidity, all-cause mortality, and reduced quality of life associated with moderate to severe OSA, adequate treatment is imperative.
Alternative treatment options for select patients unable to tolerate CPAP include oral appliance therapy, positional therapy, weight loss, and upper airway reconstructive surgery.

3.4 The strengths of the study

The study followed a systematic process to search for evidence on the current use of UPPP and its variations in the management of OSA in adults. The surgical management of OSA remains an area of much debate in clinical practice. Therefore, this study also aimed to review the current global trends in this area and demystify the concept of surgery for OSA in adults and bridge the knowledge gap. During the search for relevant literature, we included studies published in all languages. This was done to eliminate some selection bias in this study. This study used a scoping review methodology that enabled us to conduct an extensive search of all literature to answer our research question. This method also allowed the inclusion of all study designs. There was a high degree of agreement between screeners, which was calculated after the full article screening stage.

3.5 The limitations of the study

Despite the above-mentioned strengths, this study has some limitations, which need to be considered. Patient inclusion and exclusion criteria varied between studies, and the severity of OSA was also quite different. Many of the included studies were relatively small in terms of patient recruitment, which limits the power of the conclusions drawn in them. This is somewhat addressed by combining results; however, the total number of patients in all of the studies combined is 748, which is still likely underpowered to detect differences given the number of procedures being compared**.** The study duration of 5 years is noted as limitation in broadly drawing conclusions with regards to the current trends on the surgical management of OSA in adults.

3.6 Recommendations for future research

Surgical management of OSA remains an area of much debate and differing opinions amongst otorhinolaryngologists. Many of the included studies had a limited number of participants, and only two were randomized clinical trials. This presents a methodological gap in the literature. Additional studies are needed to look at the development of preoperative workup protocols in LMIC's including sub-Saharan Africa that may not have facilities for drug-induced sleep endoscopy and dynamic neck MRI readily available. We would also like to recommend more studies to look at the long-term quality of life outcomes of the newer oropharyngeal procedures for OSA, i.e., transoral robotic surgery, modified radiofrequency tongue base tissue ablation, hypoglossal nerve stimulation, etc.

3.7 Implications for practise

Evidence from this scoping review indicates that oropharyngeal surgery is a viable option for the management of OSA in those patients that fail CPAP use. Pre-operative sleep endoscopy is indicated to document the pre-operative AHI for comparative purposes with postoperative

outcomes. Management of OSA in adults requires a multi-disciplinary approach with a team that includes dieticians, psychologists (psychosocial support, behavioral changes, and weight loss), neurologist's/sleep physicians (sleep studies, DISE, and to rule out neurological aetiological factors), and otorhinolaryngologists for the surgical planning. Multilevel surgery that targets mainly the base of the tongue and soft palate has shown better outcomes compared to unilevel surgery. A surgical plan is to be tailor-made to each patient based on the outcome of their preoperative investigations. Long-term follow-up and assessment of the quality of life outcomes is also essential to document.

3.8 Conclusion

UPPP remains a valid surgical option for managing OSA. However, alternative procedures aimed at multi-level approaches, hypoglossal nerve stimulation, and procedures targeting retropharyngeal obstruction inclusion relief of tongue-base obstruction are gaining favor. Variations to UPPP mainly targeting the anterior palate plus simultaneous palatine tonsillectomy in combination with the base of tongue tissue ablation or transoral robotic surgery for OSA as part of a multi-level surgical approach yielded the most favorable post-operative outcomes as measured by subjective parameters as well. Preoperative assessment of the level of obstructions to plan targeted surgery is recommended.

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Appendix 1: The final Study Protocol (Includes the final protocol which was given full approval by Brec and/or the postgrad office)

Title: The evidence on the surgical management of obstructive sleep apnoea (OSA) in adults with focus on Uvulopalatopharyngoplasty: A systematic scoping review

Research Protocol

Winile Makhaye[1], Jacqueline Van Wyk[2]

[1]Correspondence to

Winile Makhaye

winilemakhaye@yahoo.com; Discipline of Otorhinolaryngology, School of Clinical Medicine, University of KwaZulu Natal, Durban 4001, South Africa

[2] Discipline of Clinical and Professional Practice, College of Health Sciences, University of KwaZulu Natal

Durban, South Africa. vanwykj2@ukzn.ac.za

Title: The evidence for the surgical management of obstructive sleep apnoea (OSA) in adults with focus on UPPP: A systematic scoping review

Abstract

Background

Obstructive sleep apnoea (OSA) is a disease characterized by intermittent and repetitive narrowing of the airway during sleep. Surgical therapies for the treatment of OSA aim to improve airway patency by addressing selected site(s) of obstruction [1]. Due to the episodic hypoxia, arousal and sleep fragmentation associated with OSA, it has an impact on daytime alertness and cognitive function with increased risk of cardiovascular disease and metabolic disorders. Some of the predisposing factors for OSA are older age, male gender, craniofacial abnormalities and obesity. Surgery for obstructive sleep apnoea/hypopnoea syndrome is aimed at alleviating symptoms of daytime somnolence, improve quality of life, and reduce the signs of sleep apnoea recorded by polysomnography. However, surgery is usually reserved as second line treatment in those patients that fail or do not tolerate CPAP. It has been postulated that several areas may be responsible for the narrowing, and therefore different surgical procedures that target different areas of the upper aero digestive tract have been proposed in the management of OSA. The proposed scoping review is aimed at mapping evidence for the use of Uvulopalatopharyngoplasty(UPPP) in the management of OSA in adults either as a standalone procedure or in combination with other oropharyngeal procedures. UPPP is one of

the historical procedures first introduced by Fujita et al. for the management of OSA in adults. Over the years it has fallen out of favour because it had multiple post-operative complications and long term morbidity. Therefore, this scoping review seeks to map out evidence in the evolution of the surgical procedures for the management of OSA, with specific interests in UPPP in its original standard technique, to assess for any modifications to the UPPP procedure, and to assess outcomes in these trends of UPPP as a standalone procedure or in combination with other oropharyngeal procedures. The findings of this review will identify gaps in the literature and inform future research and practice.

Methods

The proposed scoping review will be guided by the enhanced version of Arksey, H., and O'Malley's scoping review framework and Leval et al 2010 recommendations as well as 2015 Joanna Briggs Institute 2017 guidelines. We will conduct a comprehensive keyword search for relevant studies published between January 2015 and December 2019, presenting evidence on the surgical management of OSA in adults from PubMed, Google Scholar, EBSCOhost (Academic search complete, CINAHL, MEDLINE) and WEB of Science databases. In addition, we will search for relevant grey literature from university repositories as well as international organizations such as the World Health Organization (WHO). We will present the results of the review using the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-analysis: Extension for Scoping Review). We will employ NVivo version 12 software package to extract the relevant outcomes from the included articles using content thematic analysis. We will conduct quality appraisal of the included articles using the mixed methods appraisal tool (MMAT) version 2018.

Discussion: It is anticipated that the results of the proposed study will inform future research and reveal useful information to guide clinicians managing patients with OSA that require surgery.

Ethics and dissemination: This study will not include human or animal participants. Data will be sourced from published literature.

Keywords:

obstructive sleep apnoea (OSA), adults, surgical procedures, uvulopalatopharyngoplasty, multi-level surgery, laser assisted uvulopalatoplasty, apnoea-hypopnea index.

Introduction and background

Obstructive sleep apnoea (OSA) is characterised by repetitive closure of the upper airway resulting in repeated, reversible blood oxygen desaturation and sleep fragmentation. In the general population, the prevalence of adult OSA was estimated in the 1990s to be approximately 20% as defined by an apnoea hypopnoea index (AHI) >5 events/h of sleep. The prevalence of 'OSA syndrome', a clinical entity defined by an elevated AHI in conjunction with daytime somnolence, was estimated to be 4% in adult men and 2% in adult women. [8] However, given the recent global trend for increasing obesity and ageing of populations, it is likely that there has been an increase in the prevalence of OSA.

Data suggests that only 25 % of patients present with a uni-level obstruction, and approximately 75 % had multi-level obstruction sites [9]. Evidence has shown that single-site surgery has a poor result when multilevel obstruction is present. By combining surgical procedures to address multiple levels of obstruction, the success rates can reach as high as 95 % in staged surgical protocols [10]. Sleep disordered breathing is associated with increased mortality and high cardiovascular risk, and therefore warrants active treatment [11]. Leaving patients who cannot use first-line therapy (CPAP) without any treatment option is in accordance with good medical practice. Although surgical therapy does not always cure OSA, it does provide significant benefits. Surgery improves disease severity, reduces early mortality risk and cardiovascular risk [12]. Studies have shown improvement in reaction time, quality of life, and motor vehicle crash risk [13]

CPAP is the first-line treatment of OSA. However, CPAP can only be considered effective if the device is being used by the patient. Many patients reject CPAP due to various issues [1]. And as a result of poor compliance, CPAP success rates in the treatment of OSA remains poor.

Methodology

Systemic scoping review

We will conduct a systematic scoping review of peer-reviewed and grey literature on the surgical management of OSA in adults with focus on Uvulopalatopharyngoplasty as a standalone procedure or combined with other oropharyngeal procedures for OSA. The review will include a quality assessment. This review will be guided by Arksey and O'Malley's [Arksey H, O'Malley L. Scoping studies 2005] scoping review framework which stipulates the following steps:

1. Identifying the research question

2. Identifying relevant studies

3. Study selection

4. Charting the data

5. Collating, summarising and reporting the results

Identified research question

The research question is: What is the current evidence on the use of UPPP as a stand-alone procedure or in combination with other oropharyngeal procedures for the management of OSA in adults?

The research sub questions are as follows:

4. What variations of UPPP have been developed in the past 5 years (January 2015–December 2019)?
5. Are the post-operative outcomes of UPPP and/or its variations comparable to those of other oropharyngeal procedures for OSA?
6. Is preoperative polysomnography done in all patients before oropharyngeal surgery for OSA?

Eligibility of the research question for a scoping review

Our research question is: What is the current evidence for the use of UPPP as a standalone procedure or in combination with other oropharyngeal procedures for the management of OSA in adults?

We use the Population, Concept and Context (PCC) mnemonic to determine the eligibility of our research question for a scoping review study (Table 1).

Table 1 – A PCC Framework for eligibility of studies

Determinant	Description
Population	Patients with obstructive sleep apnoea.
Concept	Uvulopalatopharyngoplasty as standalone or in combination with other oropharyngeal procedures for the management of OSA
Context	In the context of adults. We define adults as per the WHO definition of 19 years of age or above. Obstructive sleep apnoea can also affect children but studies reporting on children will be excluded.

Identifying relevant studies

Primary studies with a clear empirical base utilising qualitative, quantitative and mixed methods published in peer-reviewed journals as well as in grey literature addressing the research question will be included. An electronic search of the following databases will be conducted: PubMed/MEDLINE, Google Scholar, Union Catalogue of Theses and Dissertations (UCTD) via SABINET Online and World Cat Dissertations and Theses via OCLC. Websites such as the World Health Organisation (WHO) and governmental websites will be searched for policies and guidelines on the surgical management of OSA. Studies will be identified by searching literature published in any language from January 2015 to December 2019. A hand search through the main published texts used in otorhinolaryngology teaching and practise will also be conducted. Articles will also be searched through the 'Cited by' search as well as citations included in the reference lists of included articles. The search terms will include obstructive sleep apnoea, uvulopalatopharyngoplasty, laser assisted uvuloplasty, apnoea hypopnea index, adults. After searching, duplicates will be removed and the studies will be screened against the inclusion and exclusion criteria.

Keywords Search	Date of Search	Search Engine	Number of publications retrieved
(((obstructive sleep apnea [MeSH Terms]) AND (uvulopalatopharyngoplasty[MeSH Terms])) AND (upper airway surgery)) OR (upper airway surgical procedure)	15/01/20	PubMed	1191

PRISMA 2009 Flow Diagram

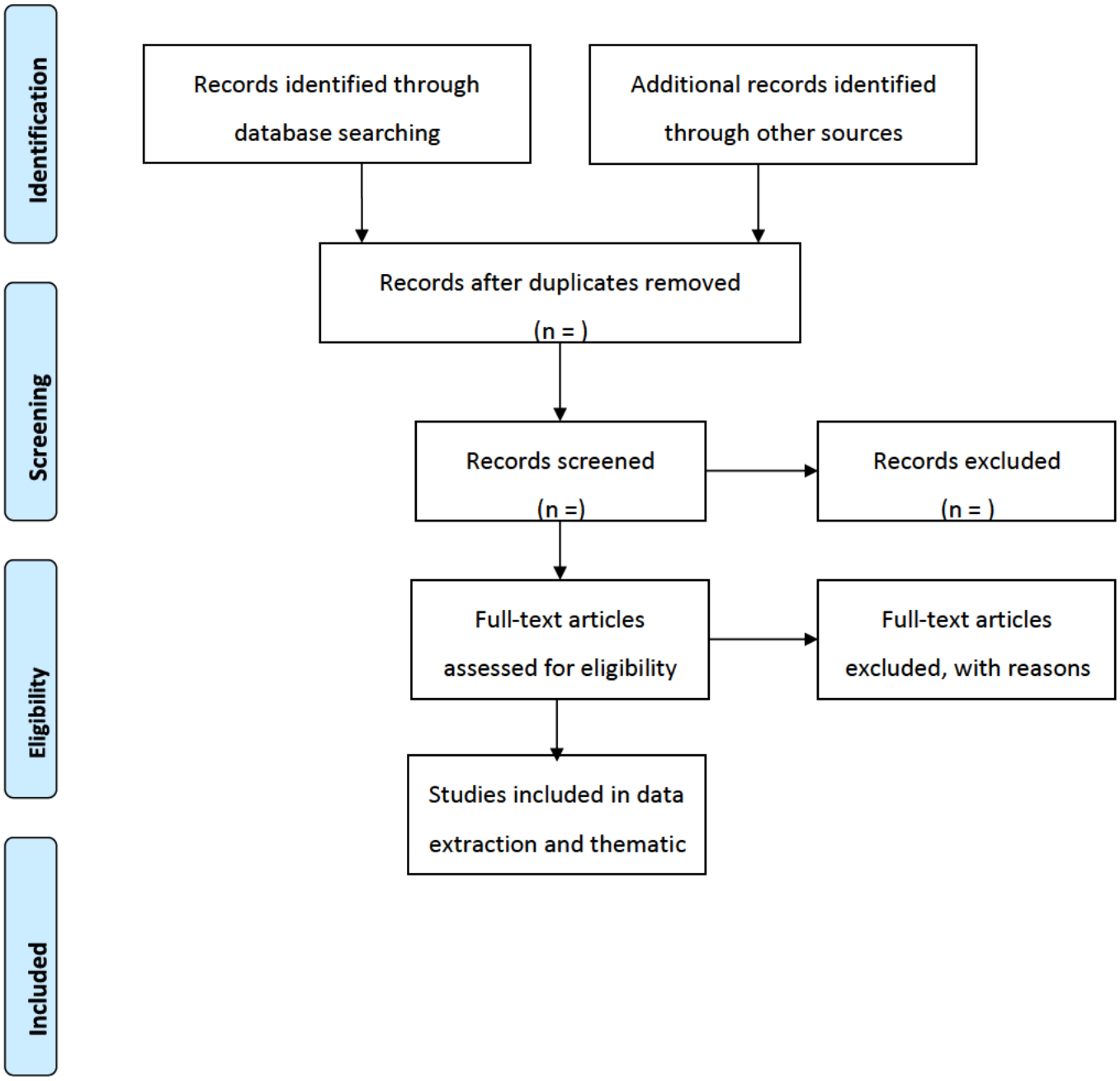

Fig. 1 PRISMA flow chart demonstrating literature search and selection of studies

Study selection (screening)

A two-stage screening process will be used to assess the relevance of studies identified in the search. Two reviewers will independently evaluate and apply the identified selection criteria to candidate literature titles and abstracts. Titles and abstracts will be screened as 'include', 'exclude' or 'uncertain'. Full text of articles screened as 'uncertain' will be reviewed by the third reviewer for verification against the inclusion criteria. During the first stage, only the title and abstract of citations will be reviewed to preclude articles that do not meet the minimum inclusion criteria. A title and abstract relevance screening form will be developed and pretested on a convenience sample of 10 academic citations to evaluate reviewer agreement. A kappa calculation will be done based on the results of this pre-test. This will in turn be used to show the reviewers' inter-rater agreement level. Generally, a kappa score over 0.8 is considered a high level of agreement.25 In accordance with recommendations by Levac et al, after reviewing every batch of 20 to 30 publications, the reviewers will meet to resolve any conflicts and ensure consistency with the research question and purpose. Executive summaries in grey literature will be treated as abstracts. Relevant titles whose abstracts are not available will be taken to screening stage 2 for full review. During screening stage 2, reviewers will independently screen the rest of the search results using the predefined inclusion–exclusion criteria. Any ensuing discrepancies will be resolved by discussion or the involvement of the third reviewer. To capture and present the screening process, the Preferred Reporting Items for Systematic and Meta-Analyses flow diagram in figure will be used.

Inclusion criteria

Studies that meet the following criteria will be included:

- Focus on obstructive sleep apnoea in adults.
- Report on UPPP as a standalone procedure or in combination with other oropharyngeal procedures OSA in adults.
- Report on the results of pre and post-operative polysomnography or sleep study.
- Published from January 2015 to December 2019.
- Qualitative and quantitative studies, as well as abstracts from conferences.

Exclusion criteria

Articles will be excluded if they have any of the following characteristics:

- Studies conducted on children
- Researched on patients with sleep disordered breathing not meeting criteria for obstructive sleep apnoea
- Studies that report on weight loss surgery as part of the surgical management of OSA
- Studies where full text article could not be obtained.
- Evidence from textbooks.

Charting the data

After title and abstract screening, the selected studies will be exported to endnote bibliographic dataset for subsequent full-text review. Endnote library application will be used to discard any duplicates. A data abstraction spreadsheet will be developed collectively by the reviewers to extract predetermined variables and themes. It will be secured online so that involved reviewers will have access and can make updates freely. Bibliographic details, study design, number of participants, type of surgical procedure, study setting, study outcomes and conclusions for the primary and secondary outcomes of interest will be extracted (Table 1). This dataset will be populated from each selected paper.

Table 2. Data Charting Form

Author and publication year
Study Title
Type of research methods
Context
Included population
Type of surgery
Study Design
Most relevant findings
Significant findings
Conclusions

Risk of bias (quality) assessment of individual studies

Methodological quality of quantitative, qualitative and mixed-method primary studies will be assessed using the Mixed Methods Appraisal Tool. Studies will not be excluded on account of low-quality scores, but quality scores will be reported and considered in the narrative synthesis of the evidence.

Collating, summarising and reporting the data

The extracted data will be summarised and presented. This is in line with the purpose of a scoping review which is geared towards establishing the scope of the current evidence, summarising the results as presented across articles and not synthesising or distilling specific results. The data will be analysed accordingly to address the main aim and the three specific study questions. Further to this, the study team will scrutinise the meanings of the findings as they relate to overall purpose of the study, discuss the implications for future research, practice and policy. Data analysis will employ both quantitative and qualitative methods. After the coding and validation of the spreadsheet file, the data will be exported into STATA V.13 for analysis. Descriptive statistics will be used to summarise the data.

Frequencies and percentages will be used to describe nominal data. A basic statistical account of the amount, type, and distribution of the studies included in the review will be presented. Also, a thematic analysis and concept map of the results will be presented. Thematic analysis will be carried out using NVIVO research software.

Quality appraisal (Levac *et al*. 2010)

We will employ mixed method appraisal tool (MMAT) Version 2018 to appraise the quality of the included primary studies (21). We will use the tool to examine the aim, adequacy and methodology, study design, participant recruitment, data collection, data analysis, presentation of findings, authors' discussions and conclusions of the included primary studies. We will grade the quality of the included studies through calculating the overall percentage quality score as stipulated by the MMAT. We will grade the quality of studies with a quality score ranging from ≤50% as low quality, 51–75% will be regarded as average quality, and 76–100% will be of high quality.

Discussion

This review will focus on UPPP as a historical surgical procedure for the management of OSA in adult. It will identify trends in evolution of UPPP in the last 5 years either as a standalone or in combination with other oropharyngeal procedures for the management of OSA. The main objective for OSA surgery is to improve or eliminate the airway collapse that occurs during sleep while preserving the normal function of the upper airway, such as speech, swallowing and preventing aspiration. The gold standard for diagnosis of Obstructive Sleep apnoea is a polysomnogram (PSG) or overnight sleep study. In OSA, a PSG calculates the number of obstructive airway events/hour of sleep, known as the apnoea-hypopnea index (AHI). An AHI < 5 is considered normal. An AHI between 5 - 15 is mild OSA; 15 - 30 AHI is moderate OSA, and an AHI > 30 signifies severe OSA. [1]

Continuous positive airway pressure (CPAP) device is considered first-line treatment for OSA in adults [1]. When used properly, CPAP is effective at reducing symptoms of OSA and cardiovascular risk [4, 5]. However, CPAP efficacy is limited by patient compliance to therapy. In the literature, the reported adherence to CPAP ranges from 30 to 70 % [1]. For patients who are not compliant with CPAP or who are intolerant of it, physicians must consider other treatment options and surgery is one of the alternative therapies. In the literature, surgical success has been defined as a reduction of the Apnoea Hypopnea Index AHI by 50 % and AHI < 20 post operatively, surgical cure is defined as an AHI < 5 [1] Other goals of surgery include improvement of sleep quality, improvement of the AHI and oxygen saturation levels. The anatomical cause of OSA is heterogeneous with multiple potential levels of airway obstruction, therefore many different surgical procedures have been developed for the treatment of OSA. A

surgical treatment plan is made according to the potential site(s) obstruction and it is tailored according to the specific needs of individual patients.

Data suggests that only 25 % of patients present with a uni-level obstruction, and approximately 75 % had multi-level obstruction sites [Lin H-C 2008]. Evidence has shown that single-site surgery has a poor result when multilevel obstruction is present. By combining surgical procedures to address multiple levels of obstruction, the success rates can reach as high as 95 % in staged surgical protocols [Riley RW 1993]. UPPP remains one of the commonest surgical procedures use in the management of OSA in adults. Due to significant morbidity, in recent years there has been a move in the literature to modify traditional UPPP to a less invasive procedure or to combine it with less invasive procedures to improve outcomes. This study aims to look at the most current literature on the use of UPPP in the management of OSA either in its traditional standard form or in a modified form which may be combined with other upper airway surgical procedures.

The study findings will also be made available to general practitioners, primary health care providers and sleep physicians.

List of abbreviations

OSA - Obstructive Sleep Apnoea

UP - uvulopalatoplasty

UPPP - Uvulopalatopharyngoplasty

AHI - Apnoea Hypopnoea Index

CPAP - Continuous Positive Airway Pressure

Declarations

Nil

Ethics

This study will not include humans or animals as participants. Data will be sourced from published literature.

Consent for publication

Not applicable

Availability of data and materials

All data generated or analysed during this study will be included in the published scoping review article.

Funding

Nil

Authors contributions

Acknowledgments

The author was assisted by the UKZN Systematic Review service in developing this protocol.

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Reporting results of obstructive sleep apnoea syndrome surgery trials. Otolaryngology Head Neck Surg 2011;144: 496–499.

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Appendix 2: BREC Approval

UNIVERSITY OF KWAZULU-
NATAL INYUVESI
YAKWAZULU-NATALI RESEARCH OFFICE
BIOMEDICAL
RESEARCH ETHICS ADMINISTRATION
Westville Campus
Govan Mbeki Building Prtvate Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA Tel: 27 312604769
Fax: 27 31 260-4609
Email: BREC@ukzn.ac.za
Website: http:/[rese arch. Ljkzn. ac.za/Research-Ethics /Biornedical- Research-Ethics. as ox

12 June 2019

Dr WP Makhaye (203508809) School
Clinical medicine
College of Health
Sciences
winilemakhave@vahoo.c
om

Dear Dr Makhaye

Protocol: Surgical Management of obstructive sleep apnoea (OSA) in adults: A scoping systematic review Degree: MMED
BREC REF: EXM440/19

I refer to your application to BREC received on 06 June 2019 and wish to advise you that exemption of ethics review has been granted for this study.

This exemption will be noted at the next Biomedical Research Ethics Committee meeting to be held on 09 July 2019. Yours sincerely

[redacted]
Prof D Wassenaar
Acting Chair: Biomedical Re Research Ethics Committee

cc: Postgrad administrator Supervisor:
Vanwyki2@ukzn.ac.za

Appendix 3: Data collection tools (for example)

Table 3- Data charting form
Author and date
Title of study
Publication

Aim of study
Study setting
Study population
Study design
Surgical procedure
Data collection methods
Data analysis
Conclusion
Most significant findings
Comment

Appendix 3: MMAT Tool (attached as a separate document) Appendix 5: PRISMA ScR Checklist

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Evidence on the surgical management of Obstructive Sleep Apnoea in adults with for on uvulopalatopharyngoplasty: A Scoping Review	1
ABSTRACT			
Structured summary	2	**Objective:** To conduct a scoping review to systematically map the evidence on the surgical management of obstructive sleep apnoea (OSA) in adults with focus on uvulopalatopharyngoplasty (UPPP) over the past 5 years (2015-2019). **Method**: Scoping review based on the recommendations of the Joanna Briggs Institute (JBI) and the Preferred Reporting Items for Systematic reviews and Meta-Analyzes extension for Scoping Reviews (PRISMAScR) to be carried out in five steps: 1. Identification of the research question (What is the current evidence on the use of UPPP as a stand-alone procedure or in combination with other oropharyngeal procedures for the management of OSA in adults?); 2. Identification of relevant studies (a search will be carried out in eight databases, in Google Scholar and in the reference lists of selected articles); 3. Selection of studies (original articles, research protocols and dissertation published between January 2015 to December 2019 reporting on UPPP and variations for the management of OSA); 4. Extraction of the collected data (the data will be extracted and stored in a spreadsheet made specifically for this study); and 5. Reporting the results (the results of this study will be analysed quantitatively, using frequencies and percentages, and qualitatively, using themes)	2
INTRODUCTION			
Rationale	3	Approximately 1 billion of the world's population of 7.3 billion people, between the ages of 30 and 69 years, are estimated to have the most common type of sleep-disordered breathing, obstructive sleep apnoea (OSA) [36]. OSA prevalence is rising and affects all countries. The increase in prevalence is driven by the global increase in obesity, the major risk factor for OSA [37]. CPAP remains the first line of treatment in these patients, however, it can only provide relief when used appropriately. Pinto et al, reported that in spite of several benefits of CPAP therapy, compliance remains a big problem both in the inpatient and outpatient setting. And this is generally due to patient discomfort with the CPAP mask [9]. Surgery therefore becomes an alternative for those patients who struggle to tolerate CPAP. This study aims to map out evidence on the use and current modifications to UPPP, a historical surgical procedure for the management of OSA.	3
Objectives	4	To determine current evidence regarding the use of UPPP and its variations as a stand-alone procedure or in combination with other oropharyngeal procedures for the management of OSA in adults. To reveal gaps in research on the modifications of UPPP and their post-operative outcomes on the surgical management of OSA	4

<table>
<tr><th>SECTION</th><th>ITEM</th><th>PRISMA-ScR CHECKLIST ITEM</th><th>REPORTED ON PAGE #</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><th>Determinant</th><th>Description</th></tr>
<tr><td>Population</td><td>Patients with obstructive sleep apnoea.</td></tr>
<tr><td>Concept</td><td>Uvulopalatopharyngoplasty as standalone or in combination with other oropharyngeal procedures for the management of OSA. UPPP involves resection of the uvula, distal margin of the soft palate, palatine tonsils, and any excessive lateral pharyngeal tissue,</td></tr>
<tr><td>Context</td><td>In the context of adults. We define adults as per the WHO definition of 19 years of age or above. Obstructive sleep apnoea can also affect children but studies reporting on children will be excluded.</td></tr>
</table>
</td><td></td></tr>
<tr><td colspan="4">METHODS</td></tr>
<tr><td>Protocol and registration</td><td>5</td><td>Review Protocol submitted to the University of Kwa-Zulu Natal Research and Ethics Committee for approval.</td><td>5</td></tr>
<tr><td>Eligibility criteria</td><td>6</td><td>Original articles, research protocols, dissertation published between January 2014 and December 2019 reporting on the surgical management of OSA in adults by way of UPPP and/or variations, published in any language will be included. Quantitative, qualitative and mixed methods studies will be included. Sites, media commercials and posters were excluded.</td><td>6</td></tr>
<tr><td>Information sources*</td><td>7</td><td>In January 2020, the following databases were searched: PubMed/MEDLINE, Google Scholar, Union Catalogue of Theses and Dissertations (UCTD) via SABINET Online and World Cat Dissertations and Theses via OCLC. Websites such as the World Health Organisation (WHO) and governmental websites were searched for policies and guidelines on the surgical management of OSA.</td><td>7</td></tr>
</table>

Search	8		**Keywords Search**	**Date of Search**	**Search Engine**	**Number of publicati**	8

<table>
<tr><th>SECTION</th><th>ITEM</th><th>PRISMA-ScR CHECKLIST ITEM</th><th>REPORTED ON PAGE #</th></tr>
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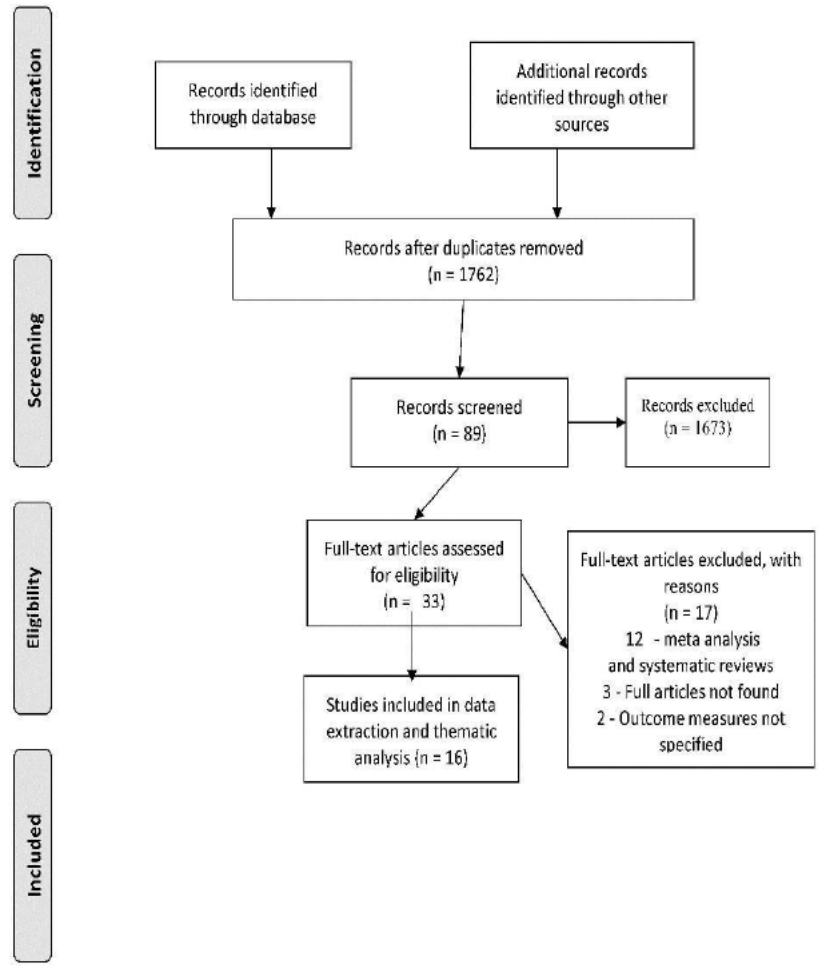
<tr><td>(((obstructive sleep apnea[MeSH Terms]) AND (uvulopalatopharyngoplasty[MeSH Terms])) AND (upper airway surgery)) OR (upper airway surgical procedure)</td><td>15/01/20</td><td>PubMed</td><td>1191</td></tr>
</table>
</td><td></td></tr>
<tr><td>Selection of sources of evidence †</td><td>9</td><td>Inclusion criteria
Studies that met the following criteria were included:
• Focused on Obstructive Sleep Apnoea in adults
• Reported on surgical management of OSA in adults with focus on UPPP and/or its variations
• Reported on the results of pre and post-operative polysomnography or a sleep study
• Published from January 2015 to December 2019
• Qualitative and quantitative studies, as well as abstracts from conference proceedings

Exclusion criteria
Studies were excluded if they had any of the following characteristics:
• They were conducted with children as participants
• Researched on patients with sleep disordered breathing not meeting criteria for OSA
• Studies where full text article could not be obtained
• Studies reporting on weight loss surgery as part of management of OSA
• Evidence from textbooks
• Literature reviews</td><td>9</td></tr>
<tr><td>Data charting process ‡</td><td>10</td><td>Author and publication year</td><td></td></tr>
</table>

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Synthesis of results	13	We provided a narrative account of the evidence revealed from the studies included. The data was analysed using thematic content analysis. The implications of data findings were analysed by the review team to check how they related to the research aims and objectives.	8
RESULTS			
Selection of sources of evidence	14	**PRISMA 2009 Flow Diagram** 	10
Characteristics of sources of evidence	15	Characteristics of included studies table	13
Critical appraisal within sources	16	MMAT Tool attached (Appendix 4)	67

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
of evidence			
Results of individual sources of evidence	17	Table characteristics of included studies	13
Synthesis of results	18	The literature searches and selection method is illustrated in Figure 1. A total number of 1981 articles were initially identified after title screening (Figure 1). We deleted duplicates, which resulted in the exclusion of 1673 articles. A total number of 89 abstracts were screened. Of these, 33 were selected for full article screening. Subsequently, 17 articles were excluded after the full article screening. Sixteen (16) of the 33 articles met the inclusion criteria and were included for data extraction. The reasons for this exclusion are as follows: twelve studies were literature reviews; three studies, full articles were not found; the last two studies to be excluded did not specify their outcome measures. Analysis of the results of full article screening show that there was 76.92% agreement versus 58.12% expected by chance which constitutes a considerably poor agreement between screeners (Kappa statistic = 0.45 and p-value <0.05). However, the McNemar's chi-square statistic suggests that there is no statistically significant difference in the proportions of yes/no answers by reviewer with p -value >0.05 (Appendix A). A third reviewer was appointed to resolve the discrepancies presented in full article screening results. The sample size of the studies included are presented in Figure 2 and 3.	9
DISCUSSION			
Summary of evidence	19	Through thematic analysis the following trends emerged on the current evidence for the surgical management of OSA in adults. **Role of upper airway surgery in OSA** Alternative treatment options for select patients unable to tolerate CPAP include oral appliance therapy, positional therapy, weight loss, and upper airway reconstructive surgery. Oral appliance therapy is not a long term management solution. Surgery is considered second line treatment, however, as this study has shown, there is no one surgical solution that is suitable for all patients with OSA. UPPP as a historical procedure for OSA has undergone modifications aimed at reducing morbidity over the years, however the post-operative outcomes with regards to objective success have remained similar. However, the absolute indications for surgery are not clearly defined in the literature and therefore further research is needed to address this gab. . **Base of tongue targeted procedures** Historically surgical procedures for OSA have focused on addressing the soft palate, lateral pharyngeal wall +/- palatine tonsillectomy. This study identified the theme of alternative procedures targeting the base of tongue, i.e. modified radiofrequency ablation of base of tongue tissue, trans oral robotic surgery posterior glossectomy, hypoglossal nerve stimulation etc. to have increasingly become an area of interest in the past five years. Studies to evaluate the quality	16

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
		of life outcomes, specifically swallowing and evaluation for any aspiration symptoms post operatively in patients who have undergone base of tongue surgery is an area of research that needs to be studied further. **Pre-operative workup and surgical planning** The main challenges that the surgeon faces in OSA management are patient selection and choice of procedure. A third theme identified that seeks to address this, is that of multi-level surgery and preoperative workup aimed at identifying the anatomical level of obstruction. Two of the included studies that examined the theme of multi-level surgery included UPPP as part of the surgery and reported favourable outcomes (site the multilevel studies). This approach was dependent on the ability to preoperatively assess the level of obstruction by way of drug induced sleep endoscopy plus dynamic neck MRI. In resource limited settings, these investigations may not be readily available. Therefore, more research is needed to look at alternative investigations that can be done in LMIC's with limited resources that can enable the provision of adequate preoperative workup for these patients. **Role of polysomnography** Sleep study remains a vital part of the diagnostic workup of OSA patients. In the surgical setting it provides valuable information to evaluation objective outcomes postoperatively. However, the literature shows that with regards to surgical workup specifically, investigations that can contribute to evaluating the anatomical level of obstruction i.e. DISE and dynamic neck MRI have become more valuable. However as sited above, these investigations may not always be readily accessible.	
Limitations	20	One of the limitations of this study is that the differences in patient inclusion and exclusion criteria varied between the included studies and the severity of OSA was also quite different. Also, many of the included studies were quite small in terms of patient recruitment, which limits the power of the conclusions drawn in them. However, this may be explained by the low prevalence of OSA in the general population. Despite these limitations, this study was able to map current evidence for the surgical management of OSA by way of oropharyngeal surgery and the variations to UPPP.	19
Conclusions	21	Surgical management of OSA remains an area of much debate and differing opinion amongst otolaryngologist. A lot of the included studies had a limited number of participants and only two were randomized control trials. This presents a methodological gab in the literature. Additional studies are needed to look at the development of preoperative workup protocols in LMIC's including sub Saharan Africa that may not have facilities for drug induced sleep endoscopy and dynamic neck MRI readily available. We would also like to recommend more studies to look at long term quality of life outcomes of the newer oropharyngeal procedures for OSA i.e. transoral robotic surgery, modified radiofrequency tongue base tissue ablation, hypoglossal nerve stimulation etc.	19

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
FUNDING			
Funding	22	This study is self-funded by the primary investigator.	20

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and MetaAnalyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. ;169:467–473. doi: 10.7326/M18-0850

				SCREENING QUESTIONS		1. QUALITATIVE STUDIES					2. RANDOMIZED CONTROLLED TRIALS					3. NON-RANDOMIZED STUDIES					4. QUANTITATIVE DESCRIPTIVE STUDIES					5. MIXED METHODS STUDIES					
RefID	First author	Year	Citation	S1. Are there clear research questions?	S2. Do the collected data allow to address the research questions?	1.1. Is the qualitative approach appropriate to answer the research question?	1.2. Are the qualitative data collection methods adequate to address the research question?	1.3. Are the findings adequately derived from the data?	1.4. Is the interpretation of results sufficiently substantiated by data?	1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?	2.1. Is randomization appropriately performed?	2.2. Are the groups comparable at baseline?	2.3. Are there complete outcome data?	2.4. Are outcome assessors blinded to the intervention provided?	2.5 Did the participants adhere to the assigned intervention?	3.1. Are the participants representative of the target population?	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	3.3. Are there complete outcome data?	3.4. Are the confounders accounted for in the design and analysis?	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	4.1. Is the sampling strategy relevant to address the research question?	4.2. Is the sample representative of the target population?	4.3. Are the measurements appropriate?	4.4. Is the risk of nonresponse bias low?	4.5. Is the statistical analysis appropriate to answer the research question?	5.1. Is there an adequate rationale for using a mixed methods design to address the research question?	5.2. Are the different components of the study effectively integrated to answer the research question?	5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	COMMENTS
1	Adreil, B.	2017	Adreil, B., Wong, E. H. C., Saraiza, A. B., Raman, R., & Amin, J. (2017). The effectiveness of combined tonsillectomy and anterior palatoplasty in the treatment of snoring and obstructive sleep apnoea (OSA). European Archives of Oto-Rhino-Laryngology, 274(4), 2005-2011.	Yes	Yes											Yes	Yes	Yes	Yes	Yes											
2	Amali, A.	2017	Amali, A., Motiee-Langroudi, M., Saedi, B., Rahavi-Ezabadi, S., Karimian, A., & Amirzargar, B. (2017). A comparison of uvulopalatopharyngoplasty and modified radiofrequency tissue ablation in mild to moderate obstructive sleep apnea: a randomized clinical trial. Journal of Clinical Sleep Medicine, 13(09), 1089-1096.	Yes	Yes						Yes	Yes	Yes	Yes	Yes																
3	Askar, S. M.	2018	Askar, S. M., El-Anwar, M. W., & Awad, A. (2018). Modified anterior palatoplasty and double suspension sutures (with or without tonsillectomy) in selected patients with obstructive sleep apnea: a preliminary report. Sleep and Breathing, 22(3), 789-795.	Yes	Yes																Yes	Yes	Yes	Yes	Yes						
4	Chi, J. C.	2015	Chi, J. C. Y., Chiang, R. P. Y., Chou, T. Y., Shu, C. H., Shiao, A. S., & Lin, C. M. (2015). The role of lateral pharyngoplasty in obstructive sleep apnea syndrome. European Archives of Oto-Rhino-Laryngology, 272(2), 489-496.	Yes	Yes						Yes	Yes	Yes	Yes	Yes																
5	Corradi, A.M.B	2018	Corradi, A. M., Valarelli, L. P., Grechi, T. H., Eckeli, A. L., Aragon, D. C., Küpper, D. S., ... & Valera, F. C. (2018). Swallowing evaluation after surgery for obstructive sleep apnea syndrome: uvulopalatopharyngoplasty vs. expansion pharyngoplasty. European Archives of Oto-Rhino-Laryngology, 275(4), 1023-1030.	Yes	Yes											Yes	Yes	Yes	Yes	Yes											
6	Haytoglu, S.	2018	Haytoğlu, S., Arikan, O. K., Muluk, N. B., Tuhanioğlu, B., & Çörtük, M. (2018). Comparison of anterior palatoplasty and uvulopalatal flap placement for treating mild and moderate obstructive sleep apnea. Ear, Nose & Throat Journal, 97(3), 69-78.	Yes	Yes						Yes	Yes	Yes	Yes	Yes																
7	Huang, E. I.	2018	Huang, E. I., Kuo, C. L., Chou, Y. T., Lin, Y. C., & Huang, S. Y. (2018). Modified Z palatoplasty with one-layer closure in one-stage multilevel surgery for severe obstructive sleep apnea. Auris Nasus Larynx, 45(4), 791-795.	Yes	Yes											Yes	Yes	Yes	Yes	Yes											
8	Marvisi, Maurizio	2015	Marvisi, M., Vento, M. G., Balzarini, L., Mancini, C., & Marvisi, C. (2015). Continuous positive airways pressure and uvulopalatopharyngoplasty improves pulmonary hypertension in patients with obstructive sleep apnoea. Lung, 193(2), 269-274.	Yes	Yes											Yes	Yes	Yes	Yes	Yes											
9	Park, D. Y.	2018	Park, D. Y., Chung, H. J., Park, S. C., Kim, J. W., Yoon, J. H., Lee, J. G., ... & Cho, H. J. (2018). Surgical outcomes of overlapping lateral pharyngoplasty with or without coblator tongue base resection for obstructive sleep apnea. European Archives of Oto-Rhino-Laryngology, 275(5), 1189-1196.	Yes	Yes											Yes	Yes	Yes	Yes	Yes											
10	Shah, J.	2018	Shah, J., Russell, J. O., Waters, T., Kominsky, A. H., & Trask, D. (2018). Uvulopalatopharyngoplasty vs CN XII stimulation for treatment of obstructive sleep apnea: a single institution experience. American journal of otolaryngology, 39(3), 266-270.	Yes	Yes																Yes	Yes	Yes	Yes	Yes						
11	Sommer, J.	2016	Sommer, J.U., Heiser, C., Gahleitner, C., Herr, R.M., Hörmann, K., Maurer, J.T. and Stuck, B.A., 2016. Tonsillectomy with uvulopalatopharyngoplasty in obstructive sleep apnea: A two-center randomised controlled trial. Deutsches Ärsteblatt International, 113(1-2), p.1.	Yes	Yes						Yes	Yes	Yes	Yes	Yes																
12	Thaler, E. R.	2016	Thaler, E.R., Rassekh, C.H., Lee, J.M., Weinstein, G.S. and O'Malley Jr, B.W., 2016. Outcomes for multilevel surgery for sleep apnea: obstructive sleep apnea, transoral robotic surgery, and uvulopalatopharyngoplasty. The Laryngoscope, 126(1), pp.266-269.	Yes	Yes											Yes	Yes	Yes	Yes	Yes											
13	Verse, T.	2015	Verse, T., Wenzel, S. and Brus, J., 2015. Multi-level surgery for obstructive sleep apnea. Lingual tonsillectomy vs. hyoid suspension in combination with radiofrequency of the tongue base. Sleep and Breathing, 19(4), pp.1361-1366.	Yes	Yes						Yes	Yes	Yes	No	Yes																The methodology section states both procedures were perfomed under the supervision of the same senior surgeon, however, it does not specify if the outcome assessors were blinded to the intervention provided.
14	Vicini, C.	2017	Vicini, C., Meccariello, G., Cammaroto, G., Rashwan, M. and Montevecchi, F., 2017. Barbed reposition pharyngoplasty in multilevel robotic surgery for obstructive sleep apnoea. Acta Otorhinolaryngologica Italica, 37(3), p.214.	Yes	Yes																Yes	Yes	Yes	Yes	Yes						
15	Wu, H.	2016	Wu, H., Yin, Y., Ma, H., Wang, Q., Da, P. and Yue, H., 2016. Outcome comparison of two methods of pharyngeal cavity reconstruction in uvulopalatopharyngoplasty. Acta oto-laryngologica, 136(8), pp.847-851.	Yes	Yes																					Yes	Yes	Yes	Yes	Yes	
16	Zhang, X. M.	2015	Zhang, X.M., Tham, C.J., Yin, Y.L., Sun, Y.Q. and Zhou, X., 2015. A novel palatal implant surgery combined with uvulopalatopharyngoplasty and inferior turbinate radiofrequency for the treatment of moderate to severe obstructive sleep apnea: a pilot study. European Archives of Oto-Rhino-Laryngology, 272(5), pp.1195-1202.	Yes	Yes																Yes	Yes	Yes	Yes	Yes						