Management of the Concha bullosa:

A systematic review

ABSTRACT

Background

An obstructive anatomical variation in patients with chronic sinusitis with high prevalence is known as pneumatization of the concha bullosa. Many techniques described the management of concha bullosa which includes radial excision of the middle turbinate, minimal excision of the lateral or medial lamella, transverse excision, crushing of the middle turbinate and microdebrider turbinoplasty. The outcomes of all the techniques showed improvement in the life quality of the patients, so it is difficult to find the best available technique for management of concha bullosa. In addition, there are only a few studies that compare these techniques for surgical outcomes.

Aim

The aim of the study is to determine the appropriate technique for the management of concha bullosa. The purpose of this dissertation is to evaluate the literature available on online databases and analyse the different techniques applied for the management and reduction of concha bullosa.

Objective

The study also analyzed the safest and effective technique in the management of CB, which cuts across the various patients' demographics.

Method/Design

This Systematic review and meta-analysis are consisted of a comprehensive literature search of relevant electronic databases. The search criteria include studies that completely meet specific inclusion and exclusion criteria and investigates the various techniques in the management of concha bullosa. The PRISMA guidelines were used to validate the search process of a systematic review. The systematic review and meta-analysis retrieved studies from the year 1998 to 2018 related to the management of concha bullosa or its anatomical variants.

Data Analysis

A systematic review indorsed critical analysis of different research studies related to surgical or medical management of concha bullosa. CASP (critical appraisal skills

programme) were used to perform the analysis as it followed in an organized manner to appraise existing evidence in the study.

Results

Twelve scholarly articels were analysed out of which, ten studies were qualitative and two were review articles. The findings of the study entails that concha bullosa is an anatomical variant of sino-nasal region and is generally asymptomatic, yet in instances of extensive aeration, may cause side effects such as head pain (secondary to mucosal contact), blockage of the nasal cavity, and diminished sinus drainage (Kantarci et al., 2004). Further, people might develop more complications in their nasal area and seek medical help. The finding revealed that there are many techniques available that can manage concha bullosa and its variants. Surgical management of concha bullosa is more effective and result oriented in comparison to medical management or medication. Endoscopic sinus surgery, turbinoplasty, lateral laminectomy of the middle turbinate and crushing techniques are some of the popular surgical techniques available for the treatment of concha bullosa.

Significance

The significance of the study was to discuss the most appropriate technique for management of concha bullosa. There are many studies available for the treatment of concha bullosa, comparison of techniques used for concha bullosa and anatomy of concha bullosa but there is no study that clearly discusses most appropriate management technique for concha bullosa. The study explained that there is no medical treatment available for concha bullosa. Surgery is the only treatment.

Conclusion

This systematic review recognized and surgically appraised the evidence, specifically available for the management of concha bullosa. These reported outcomes recommended the requirement of learning new surgical techniques for the management of concha bullosa.

Key words: “concha bullosa”, “endoscopic sinus surgery”, “turbinoplasty”, “pneumatized middle turbinate” “management of concha bullosa” “treatment techniques for concha bullosa”

Chapter 1: Introduction

Background:

Concha bullosa (CB) is an anatomic variation of the sinonasal region and is commonly observed in adults as well as in children (Al-Qudah et al., 2008). The incidence of middle concha bullosa varies between 14% and 53%. This anatomic variant can be perceived to be restricted to the vertical lamella, extend into the bulbous portion, or majorly include the vertical lamella and bulbous segment of the middle turbinate (Tomblinson et al., 2016). In human anatomy, middle concha plays a significant role in the sensing of smell, humidification of the air and the regulation of the air flow (Thimmaiah et al., 2008). In clinical practice, concha bullosa is not given much importance. However, it is most commonly found anatomical variation (Stammberger et al., 1990). The locus responsible for the pneumatisation of the middle concha is not precise; frontal recess, middle meatus, lateral sinus, ethmoid infundibulum and agger nasi are the possible regions (Jacobs et al., 1997). In the majority of the cases, symptoms are absent in the concha bullosa of the middle turbinate, however, in some cases, nasal obstruction and inflammatory sinus diseases are reported by the patients (Derin et al., 2014).

A concha bullosa is demonstrated by pneumatization of the middle turbinate or, less frequently, the superior or inferior turbinate (Shihada et al., 2012). The concha bullosa mucociliary system drains into the frontal recess or the middle meatus through the sinus lateralis (Shihada et al., 2012). Obstruction or blockage of the ostium of the concha bullosa can prompt the advancement of a mucocele and, in case of incidental or secondary infection, a mucopyocele (Sari, K et al., 2015).

The management of concha bullosa has been defined by various techniques. These may include radical excision of middle turbinate or partial excision of the lateral lamella or

medial lamella or concha crushing as middle turbinate is attached to the skull base in the majority of cases, proper care should be taken to avoid damage to this attachment when managing concha bullosa surgically. Damage to the above attachment can lead to an unstable turbinate, cerebrospinal fluid (CSF) leak and fracture at this site. A proper diagnosis and treatment are highly recommended to achieve excellent results while managing concha bullosa.

Concha bullosa has classified into three variations as per its shape and location.

- Lamellar form- vertical lamella pneumatization (45-47%)
- Bulbous form- inferior part pneumatization (20-30%)
- Big form- Vertical lamella and inferior part massive pneumatization (15-35%)

Generally, concha bullosa is a small and asymptomatic in appearance, but if it developed in a bigger size than it can disturb nasal air flow and sinus drainage. Concha bullosa has been associated with sinusitis on the basis of its size. There are two theories that describe the situations in which concha bullosa and septal deviation both exist. The first theory described that the reason of formation of concha bullosa is a septal deviation and wide side cavity will be filled by concha bullosa. The second theory described that concha bullosa deviates nasal septum. However, there is no clear evidence about both theories. Many research has been conducted on the relationship between septal deviation and sinusitis and concha bullosa which showed a significant association between them (Aktas et al., 2003). On the other side, Tunçyürek el al., (2013) observed that septal deviation was not responsible for concha bullosa but can increase pneumatization of concha bullosa with its deviation angle. Stallman et al. (2004) accepted that concha bullosa and septal deviation have shared an important relationship but denied any cause-effect relationship between concha bullosa and septum due to the existence of air passage. This

relationship does not depend on the size of concha bullosa and severity of deviation. However, concha bullosa is associated with sinusitis on the basis of its size. Yousem et al. (1991) found that the size of concha bullosa was responsible for the development of sinusitis. Although, sinusitis was not related to concha bullosa, concha bullosa was consider as a possible threat for sinusitis due to obstruction in osteomeatal complex region and formation of mucosal contact (Joe et al., 2000)

Concha bullosa is responsible for causing headache and obstruction in the nasal cavity due to narrowing of the middle turbinate. The headache occurred due to concha bullosa is influenced by recurrent pain developed in the periorbital area. Periorbital area is between the eyes or in the frontal bone and cheeks.

Clinical presentation:

In the majority of the concha bullosa cases, symptoms are absent. Albeit a few studies have recommended a connection between concha bullosa and sinus disease, other studies have not been able to demonstrate a direct relationship. Hence it remains unclear whether concha bullosa is associated with rhinosinusitis (Khalife et al., 2016). The air space inside the turbinate is prone to similar pathologies as sinuses, and subsequently, it may become infected, blocked (mucocele) or be the site for cancer growth (Mortellaro et al., 2002). Conchae bullosa is strongly related to a deviation of the nasal septum, which has itself been identified as a contributing factor for sinus disease in individual studies (Stallman et al., 2004). The size of the concha bullosa is important for the presence of symptoms. These may include:

- Rhinogenic headache
- Nasal obstruction
- Possible recurrent sinus disease

Diagnosis:

Concha bullosa is best diagnosed with a CT scan and is estimated to be found in 16 to 53 out of 100 cases (April et al., 1993). The turbinates will typically show up as a light grey colour; however, in the case of concha bullosa, there will be a black pocket of air in the middle of the grey turbinates (Pittore et al., 2011).

Concha bullosa is referred to as the pneumatisation of the middle turbinate. A similar presentation can be noted in superior and inferior turbinate, although extremely rarely. Based on the size or location of the pneumatisation, concha bullosa is classified into three types.

- lamellar: pneumatization of the vertical lamella of the concha (many authors do not regard this as a concha bullosa)
- bulbous: pneumatization of the bulbous segment
- extensive (total): pneumatization of both lamellar and bulbous parts

These types are strongly linked to nasal septal deviation, which is usually away from the concha bullosa. The surrounding air spaces are traditionally preserved. This suggests a developmental asymmetry rather than the mass effect on imaging. It is important to note that concha bullosa and deviated nasal septum can interfere with trans-nasal surgery, and hence they can be a relative finding on imaging of the area for a different purpose.

Need for this study:

Although several studies have been conducted on concha bullosa, its presentation and its relationship with sinusitis and septal deviation, not many studies have been conducted on the management strategies of this condition. Hence, no definite consensus on the management of concha bullosa exists at present. The study is conducted to review the

available management strategies of concha bullosa, including the best management technique.

Objectives

- To assess the effectiveness of concha bullosa surgery
- To compare the results of different techniques that are currently used for the management of concha bullosa in adults
- To assess both short and long term results, and the complications of the procedures

LITERATURE

Introduction

The most common anatomic variation of the middle turbinate is known as concha bullosa, and may occur in patients with sinonasal diseases (Kantarci et al., 2004). Concha bullosa is basically observed in the middle turbinate but can also be visible in the inferior or superior conchae (Ozcan et al., 2002). The space between the lateral nasal wall and the septum that is responsible for the blockage in the middle turbinate may completely be filled by concha bullosa (Moche et al., 2012). Turbinate in the nasal area lubricates and hydrates the upper respiratory system, helps in the arrangement of air flow, smelling filtration, and thermoregulation. Obstruction of the nasal passages can result into negative symptoms such as nasal obstruction, persistent headaches, postnasal discharge, impaired olfactory functions and epistaxis which adversely affect the life quality of the patient (Peric et al., 2010).

Concha bullosa as a pathological finding

Current studies have demonstrated that the presence of concha bullosa alone is not considered as a pathological finding, unless this is combined with other abnormalities such as an enlarged ethmoid bulla or a medially bent uncinate process. Even a small concha bullosa can lead to significant narrowing pf the anterior and middle part of the middle meatus when it is combined with other sinonasal abnormalities.

A concha bullosab presents as an enlarged body or head of the middle turbinate which is medially contacted with the nasal septum and laterally bulged into the lateral nasal wall. This structure makes difficult to analyse middle meatus. Anatomical variants such as concha bullosa can be analysed with the help of computer tomography. Computer tomography is the excellent tool to analyse anatomical variants.

Current mechanisms of development of concha bullosa (pneumatisation of the middle turbinate)

There are various anatomical variations were seen by the middle turbinate. Most commonly it can be ballooned out as air enclosed in it and this air cell can be pneumatised from the anterior ethmoids, agger nasi cells or frontal recess. This position of middle turbinate is known as concha bullosa. This position of concha bullosa is looks like a ballon and chunk the osteomeatal unit and anterior cluster of sinuses drainage. According to Stallman (2004), presence of concha bullosa can be established when around half of the vertical height of middle turbinate that was measured by superior to inferior in the coronal plane is pneumatised (Stallman et al., 2004). However, some specific anatomic anomalies also contributed to the chronic rhinosinusitis pathogenesis such as paradoxical middle turbinate, large ethmoid bulla, septal deviation, and concha bullosa (Browning et al., 2008). Various studies have described a concha as aeration of the middle turbinate even though, it was restricted to the turbinate non-bulbous portion (Paul et al., 2015). Some other studies described a concha bullosa as bulbous portion of the middle turbinate due to aeration (Zinreich et al., 2003). The precise mechanism of concha bullosa formation is still not clear. It is deliberated that the airflow pattern plays a crucial role in the nasal cavity for the concha bullosa formation. It is known as an e-vacue theory. The pneumatisation of the middle turbinate is enlarged in the contra-lateral site when airflow is decreased in the nasal cavity. This theory can describe the correlation of contra-lateral concha bullosa and nasal septal deviation (Aktas et al., 2003). Hatipoglu et al (2005) differentiate concha bullosa on the basis of pneumatisation location as bulbous, lamellar, and extensive. According to him, the occurrence of concha bullosa is 46.96 percent is extensive type, 32.00 percent of bulbous type and 20. 92 percent is lamellar type (Hatipoglu et al., 2005).

Concha bullosa is an ostiomeatal complex variant. Rarely, concha bullosa makes a complex structure with the development of a cyst, polyp, mucocele, or pyocele. Concha bullosa is developed as an anatomical variation of the paranasal region due to the pneumatization of the middle conchal bone (Braun et al., 2003).

The pneumatization of the concha bullosa

The pneumatization of the middle concha is divided into three categories by Bolger et al. (1991). These include the lamellar type which represents pneumatisation of the vertical lamella, the bulbous type, which is pneumatisation of the inferior part and the extensive type, when both vertical lamella and inferior part of middle turbinate are pneumatised.

Bone pneumatisation that is situated in the middle nasal turbinate can occur unilaterally or bilaterally. The presence of the air-filled cavity in the superior tubinate is not frequently occurred (Kim et al., 2010). The type of epithelium in an air-filled concha bullosa is similar to the remaining part of the sinonasal tract (Vaid et al., 2015). Concha bullosa can be unilateral or bilateral in shape and developed with a contralateral septal deviation when in unilateral position. Tonina et al. (2018) define that pneumatization of the concha bullosa or middle turbnate is considered as a most occurring variation of the ostiomeatal complex.

Concha bullosa and Nasal Septum Deviation

NSD is an asymmetry in the nasal septum. Kucybata (2017) investigated that the variants of the nasal septum and the presence of concha bullosa in the nasal cavities are related to the size of maxillary sinuses and the development of maxillary sinusitis. Many studies investigated the association of concha bullosa with septal deviation. Concha bullosa, whether it is uni or bi-lateral generally attached with deviated septum from the opposite side. According to Yigit et al (2010) contra-lateral concha bullosa was more commonly developed in the patients with septal deviation then patient without deviated septum. Uygur et al. (2003) established that the septal deviation angle has a crucial role in pneumatisation of concha bullosa from the opposite side. Grymer and Melson (1989) associated concha bullosa formation with posterior septal deviation by considering

posterior septal deviation as a genetic condition and causes air flow that further developed concha bullosa. Sazger et al. (2008) predicted that deviation is a passive outcome of concha bullosa and develop many nasal problems. Qian and Wang (2014) examined the association of bulbous concha bullosa with septal devation and revealed that 33 percent patients have high septal deviation. These findings showed that concha bullosa and septal deviation affects each other working and also developed each other.

Surgical management of concha bullosa

Usually, concha bullosa is treated surgically by crushing of the middle turbinate, medial or lateral laminectomy, and transverse resection (Smith et al., 2010). Still it is not clear which surgical technique is most effective (Marquez et al., 2002).

Braun et al. (2003) suggested using lateral lamella excision to treat concha bullosa and avoid crushing techniques or medial lamella excision on concha bullosa. Erkan et al (2017) explained that medial laminectomy is as effective as lateral laminectomy for the middle turbinate aeration. Eran et al. (2014) conducted a prospective endoscopic and radiologic examination of long-standing results of crushing and crushing with intrinsic stripping techniques. Both the techniques are used for the surgical treatment of concha bullosa. Crushing with intrinsic stripping is a simple and effective technique in comparison to only crushing. This technique lowers the middle concha volume that is visible through endoscopic and radioscopic methods. However, a research conducted by Kocak et al (2016) revealed that crushing is a simple and innocuous method for concha bullosa surgery. The study used endoscopic methods to determine highly effective crushing techniques for the concha bullosa. The long-term outcomes of the surgery have not shown any recurrence. This method is safe and effective for all kinds of concha bullosa and provide a significant reduction in volume of bulbous type concha bullosa. Kieff et al. (2009) investigated various surgical techniques used for concha bullosa as well. These

include crushing and partial or total resection of the concha bullosa. They did not identify any studies performed on the reformation of concha bullosa after crushing. They found that for the long-lasting outcomes of concha bullosa crushing, the implication of frontal sinus balloon sinuplasty was a good option as concha bullosa can reform again.

Apuhan et al. (2013) studied the controversies that exist in bullous middle turbinate surgery regarding the side of the pneumatised concha that should be removed in relation to the olfactory neuroepithelium.

The study examined the existence of functional olfactory epithelium in the middle turbinate tissue in patients undergoing endoscopic concha bullosa surgery and found Olfactory marker protein (OMP) stained nerve tissues in the medial part of the concha that covered middle turbinate with mucosa and make it difficult to perform endoscopy (Joe et al., 2000).

Gaps in literature

There are various studies available on concha bullosa, its variants and its associations with septal deviation and sinusitis, but only a few studies are currently available on the management of concha bullosa. Evidence-based management strategies, relevant literature that addresses the problem and its solution are needed to fill the gaps. There is no clear consensus on indications for surgery and on most effective and safe surgical techniques. The study is helpful in addressing gaps in strategy development and its implementation, gaps between the surgical procedure and its success rate and gaps between knowledge of the problem among people and its availability.

Outline

The surgical management of concha bullosa uses many different treatment techniques such as turbinoplasty, lateral or medial partial resection, total resection, crushing and

crushing with intrinsic stripping. An endoscopic surgical method, which is used extensively for concha bullosa is known as turbinectomy (Moses et al., 2000). However, it is not clear yet which technique is most effective for the management of concha bullosa or which side of the concha bullosa is better to open to improve nasal and olfactory functions (Jiang et al., 2002). There are many studies available that compare, evaluate or describe different techniques used for the management of concha bullosa. The present study analysed peer-reviewed studies to examine the effectiveness and safety of the techniques that are currently used in the management of concha bullosa.

CHAPTER-2

METHODOLOGY

Rationale

This systematic review assessed the effectiveness of concha bullosa surgery and compared the results of different techniques, currently used for the management of concha bullosa in adults. The study has also define both short and long term results, and the complications of the procedures/techniques.

Research question

To assess the effectiveness and safety of surgical interventions in concha bullosa treatment and its long term/short term results

Eligibility criteria

Study design

The current systematic review was conducted to assess the surgical management of concha bullosa, its effectiveness and safety and its short term and long term effect on patient quality of life. A comprehensive search was launched in the search databases for identifying the relevant studies. The study made use of the guidance provided by the Boolean operators, truncation, and wildcards to obtain better outcomes in the search. This systematic review and meta-analysis used the framework suggested by PICO to stratify the data in this review. The PICO criteria utilized in the present study are described in Table 1.

Table 1: PICO criteria for the included studies.					
Participants	**Interventions**	**Comparison**	**Outcome**	**Study design**	**Setting**
Adults (over 16 years of age) "concha bullosa" OR "middle **turbinate**" OR "pneumatized **middle turbinate"** OR Nasal Obstruction/*surgery OR Nose Diseases/*surgery OR Turbinates/*surgery OR Nasal Mucosa/***surgery**	lateral laminectomy Conchoplasty Otorhinolaryngologic **Surgical** Procedures/**methods** **Nasal** Surgical Procedures/*methods Rhinoplasty/*methods Nasal Septum/surgery partial turbinectomy Turbinoplasty	Crushing vs crushing with intrinsic stripping Partial resection vs Total resection Turbinoplasty vs endonasal sinus surgery balloon sinuplasty vs Pneumatized middle turbinate vs partial middle turbinectomy	Effectiveness of medical procedure in managing concha bullosa. Sinonasal symptoms Complications Reoperation Pain Treatment Outcome **Postoperative** Complications/prevention & control	Systematic review	Any hospital or clinic, or community settings

Types of studies:

Randomised control trials and non-randomised comparative studies of concha bullosa treatment, or comparisons between different techniques

Participants/cases

Types of participants:

Adults over 16 years of age.

Interventions

This review considered surgery as the intervention; studies that include patients who have received surgery for concha bullosa alone or as part of functional endoscopic sinus surgery were considered.

Comparison

Comparator groups of different surgical techniques were considered in this Systematic review and meta-analysis.

Setting

- Key words were selected to be used for the study
- Renowned medical databases to be reviewed.
- Year of publication to date back twenty years.
- A meta-analysis of the systemic reviews.

Inclusion criteria

Studies were used from the past twenty years. Randomised controlled trials, non-randomised comparative studies and comparisons between different techniques were considered. Patients with concha bullosa evident on CT scan and/or on endoscopic nasal examination. Patients who participated in the study must have had normal neurologic, systemic and ophthalmologic examinations. Study literature is to be limited in the English language. Patients who undertook the reviewed studies should have been above sixteen years of age. Patients who gave consent to be included in the study were considered. Availability of full-text articles and type of journal with peer reviews, specific to concha bullosa and the keywords for the study.

Exclusion criteria

Studies that were done more than twenty years ago will be excluded. Commentaries, letters to editors and editorials will be excluded as well. Patients below sixteen years of age will not be considered. Patients who do not give consent to be included in the study will be discarded. Patients with nasal septal deviation, previous sinus surgery, sinonasal polyposis, pre-existing sinus disease, nasal allergies, sinonasal neoplasms, granulomatous disease, immunodeficiency or cystic fibrosis will be excluded.

Inclusion Criteria	Exclusion criteria
Published studies on surgical management of concha bullosa (with various study designs) Studies published in 1999-2018 Studies published in English Included studies had the following focus: "Surgical management of Concha bullosa.'' Subjects of adult group of above 16 years	Studies which were not peer-reviewed Studies which were not in English Studies which are not matching the appraisal criteria. Any studies which do not clearly address surgical management of concha bullosa Any study published before 1999 was also excluded

Types of outcome measures

Primary outcomes

Improvement of subjective sensation of nasal patency as assessed by a nasal specific or quality of life symptom scoring system

Secondary outcomes

- Changes in endoscopic view and/or CT images (these will be a primary outcome measures in studies comparing hybrid procedures
- Documented adverse effects and complications
- The need for subsequent revision procedures

Electronic searches

A thorough search was launched to utilize the databases such as MEDLINE (through PubMed) and OVID, Scopus, CINAHL from January 1998 to December 2018. Databases used for the study include the Cochrane Ear, Nose and Throat Disorders Group Trials Register; the Cochrane Central Register of Controlled Trials; PubMed; EMBASE; CINAHL; Web of Science; Clinical-Trials.gov; Google Scholar and Google.

Final studies were selected from PubMed, TRIP database, The Cochrane Library and Google to retrieve existing systematic reviews relevant to this systematic review.

Search strategy

In the current study, studies for inclusion were searched on the databases such as MEDLINE (through PubMed) and OVID, CINAHL. A bibliographic search was executed according to the comprehensive guidelines of (Grewal et al., 2016) and (Lockwood and Oh, 2017). Keywords used in the search strategy were:

- Concha bullosa "OR" Surgical management of concha bullosa
- Endoscopic sinus surgery "OR" Turbinoplasty
- Pneumatized middle turbinate "OR" partial middle turbinectomy
- Treatment techniques for concha bullosa ''AND'' Medical treatment for concha bullosa

The above-mentioned keywords were united in the below-mentioned way to obtain better findings:

1. #1 And #3
2. #3 AND #2
3. #2 AND #4
4. #1 AND #2 AND 3
5. #1 AND #4
6. #1 AND #3 AND #2

Search Findings

PUBMED	**EMBASE (OVID)**	**CINAHL (EBSCO)**	
#1 "Concha Bullosa" [MeSH] #2 "pneumatised middle turbinate" [MeSH] #3 middle turbinate* [tiab] #4 #2 OR # 3 #5 "Management of concha bullosa" [MeSH] #6 "Surgical management of concha bullosa" [MeSH] #7 "Quality of life of patients" [MeSH] #8 "Prevalence and incidence of Concha bullosa" [MeSH] #9 "Clinical benefits of treating concha bullosa " [MeSH] #10 #2 OR #3 OR #6 # 11 #1 OR # 4 OR #7 OR # 8	1 Concha Bullosa/ 2 exp pneumatised middle turbinate/ 3 middle turbinate*. tw. 4 2 or 3 5 exp Management of concha bullosa/ 6 Surgical management of concha bullosa*. tw. 7 Quality of life of patients/ 8 exp Prevalence and incidence of Concha bullosa/ 9 Clinical benefits of treating concha bullosa*. tw. 10 2 or 5 or 6 or 9 11 1 or 4 or 7 or 8	S1 (MH "Concha Bullosa") S2 (MH "pneumatised middle turbinate") S3 TX middle turbinate* S4 (MH concha bullosa*) S5 TX MANAGEMENT OF CONCHA BULLOSA OR SURGICAL MANAGEMENT OF CONCHA BULLOSA OR CLINICAL BENEFITS OF CONCHA BULLOSA S6 (S2 OR S3) AND (S4 OR S5) S7 S1 OR S6	
COCHRANE	**WEB OF SCIENCE**	**ISRCTN**	**GOOGLE SCHOLAR**
#1 "Concha Bullosa" [Title/Abstract/keyword] #2 "pneumatised middle turbinate"	# 1 TS=Concha bullosa* # 2 TS= (pneumatised middle turbinate OR middle turbinate*)	(pneumatised middle turbinate OR middle turbinate)	#1 "Concha Bullosa" #2 pneumatised middle turbinate"

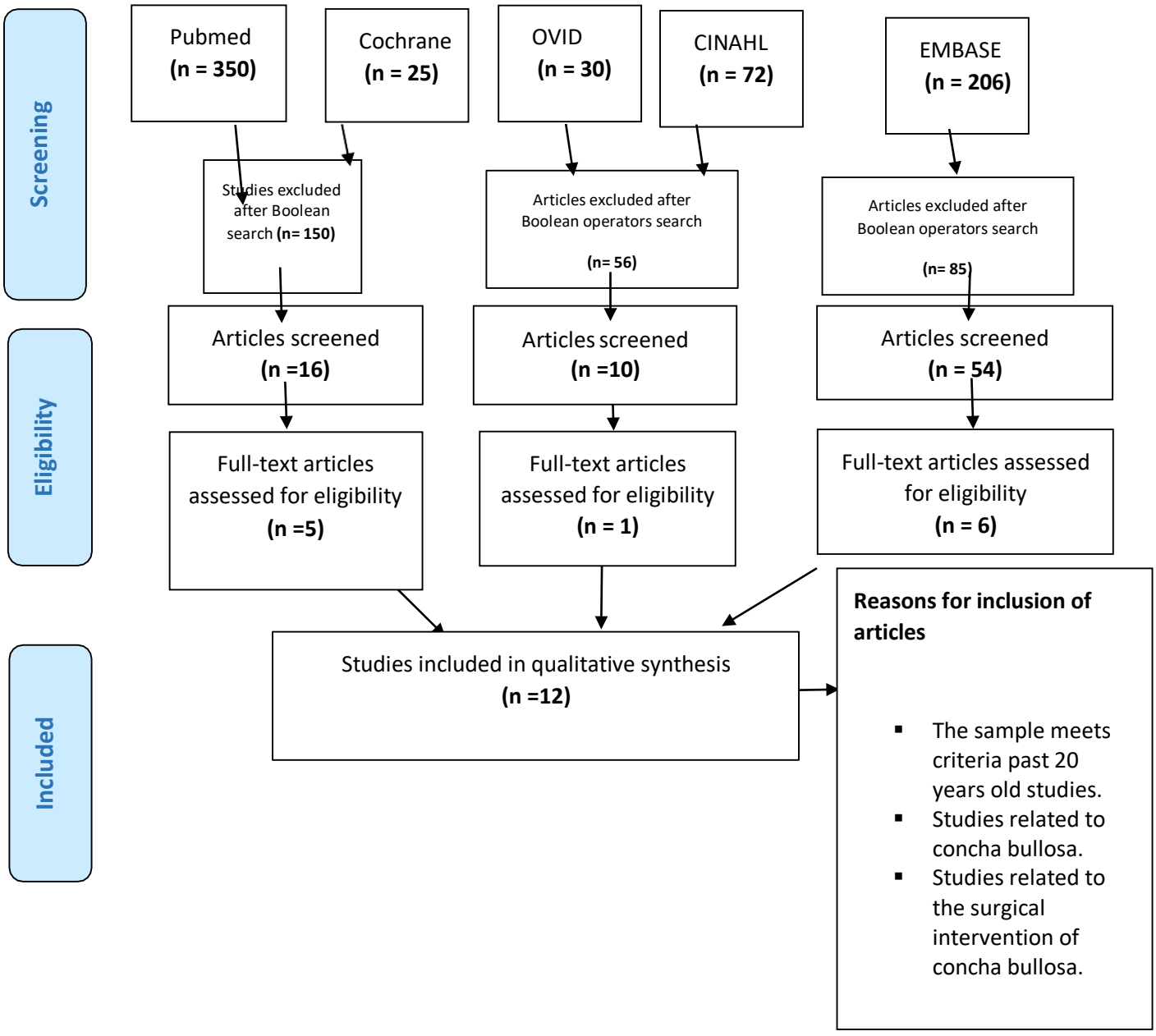
[Title/Abstract/keyword] #3 middle turbinate* [Title/Abstract/keyword] #4 #2 OR # 3 #5 "Management of concha bullosa" [Title/Abstract/keyword] #6 "Surgical management of concha bullosa" [Title/Abstract/keyword] #7 "Quality of life of patients" [Title/Abstract/keyword] #8 "Prevalence and incidence of Concha bullosa" [Title/Abstract/keyword] #9 "Clinical benefits of treating concha bullosa" [Title/Abstract/keyword] #10 #2 OR #3 OR #6 # 11 #1 OR # 4 OR #7 OR # 8	#3 #2 OR # 1 # 4 TS=(Management of concha bullosa* #5 TS=Surgical management of concha bullosa* #6 #5 OR #4	AND concha bullosa%	#3 middle turbinate* #4 #2 OR # 3 #5 "Management of concha bullosa" #6 "Surgical management of concha bullosa" #7 "Quality of life of patients" #8 "Prevalence and incidence of Concha bullosa" #9 "Clinical benefits of treating concha bullosa" #10 #2 OR #3 OR #6 # 11 #1 OR # 4 OR #7 OR # 8

PRISMA FLOW CHART

The below mention PRISMA flow chart demonstrated the procedure of including or excluding studies selected for the present systematic review. The PRISMA flow chart was created on the basis of Liberati et al. (2009) guidelines. The key words used for the search will be "concha bullosa", "partial middle turbinectomy", and "pneumatized middle turbinate". Screen all titles, abstracts and full-tests to determine eligibility. Total of 12 studies was identified. Adherence to the PRISMA will be measured according to

- The extent of data SR adherence to the PRISMA statement and extensions.
- Journal frequency on directing its authors about the PRISMA statement or extensions.

- SR adherence characteristics association, such as the year of publication and journal endorsement.
- Frequency of SR authors using PRISMA statement in their report guiding.



PRISMA FLOW CHART (Liberati et al., 2009)

Data analysis and synthesis:

Summary of surgical procedures from the selected publications which meet the study criteria. Data analysis to be conducted using STATA version 13 statistical software for cleaning, validation, coding and analysis. The coding will include coded weights of the various quantitative data to enable it to be statistically analysed. The code used will be provided. Data to be checked for any wrong or double entry and any further corrections to be made before conducting the analysis and to remove any biases. Backup of the data to be created. The descriptive analysis determines the mean, proportion of variables and frequency. A 95% ($p<0.05$) confidence interval is applied to the calculation of the proportion. Results to be presented in graphs and tables with further description analysis. Data collection and analysis include

- Selection of studies
- Data extraction and management
  Standartised data form
    - Source
    - Eligibility
    - Methods
    - Participants
    - Interventions
    - Outcomes
    - Results
    - Key conclusions of the study authors

Assessment of risk of bias

The tool recommended by The Cochrane Collaboration (Handbook 2011) was utilized. This involved assessing each study with respect to six domains, namely:

- sequence generation
- allocation concealment
- blinding
- incomplete data
- selective outcome reporting
- 'other' issues

The Robin-I tool was used (Higgins 2011; Sterne et al., 2016). This involved describing each of these domains as reported in the trial and then assigning a judgement about the adequacy of each entry. This involved answering a pre-specified question whereby a judgement of 'Yes' indicates a low risk of bias, 'No' indicates a high risk of bias, and 'Unclear' indicates unclear or unknown risk of bias.

Measures of treatment effect

- Risk Ration (RR) was used for studies reporting binary outcomes
- Standartised Mean Difference (SMD) was used for studies reporting continuous outcomes

Dealing with missing data

- Contact the original investigators to request the missing data, when possible
- If not possible an assumption will be made that the data are missing at random and will be analysed on an intention-to-treat (ITT) basis, as this is more likely to reflect real life when patients do not attend for a follow-up review

Assessment of heterogeneity

- Evaluate studies for clinical and methodological heterogeneity on the basis of the treatment protocols used and the outcomes measured in each.
- A meta-analysis was considered appropriate if treatment protocols were broadly comparable, and the appropriate outcome data are available.
- Examine statistical heterogeneity visually, using confidence intervals where available, or using the I2 statistic and the Chi2 test.

Assessment of reporting biases

- Publication bias was addressed by including trial databases in the electronic search, looking for published, unpublished and ongoing trials.
- Where potentially eligible but unpublished trials were identified, the authors were contacted to ask for results (where available).

- Multiple publication bias was addressed by combining papers that describe different results from the same study, and by excluding papers that report results that had already been published.
- Language bias was addressed by including all languages in the search strategy and obtaining a translation when necessary.
- Outcome reporting bias was addressed by assessing the risk of bias from within selective study reporting and selective under-reporting of data.

2. 10 Quality appraisal

Four levels of 3 Probability of bias will be used to appraise it depending on its evidence of bias. These are:

- Definite low bias risk; direct evidence to signify there is low bias.
- Probable low bias risk; indirect evidence to signify there is low bias.
- Probable high-risk bias; indirect evidence to signify there is low bias.
- Definite high-risk bias; direct evidence to signify there is high bias.

a) Appropriateness: this will test how closely the articles have explained the topic under study. There will also be four levels to appraise on; definite low appropriateness levels, probable low appropriateness, probable high appropriateness and definite high appropriateness.
b) Methods used to select study participants; inclusion and exclusion criteria, cases, cohorts and control groups.
c) Methods for measurement of exposure and outcomes; appropriate methods for the measurement of exposures and outcomes to be applied.

Assessment of study quality

This Systematic review has used the critical appraisal skills program (CASP) for appraising the selected studies. This program provides various checklists to evaluate the quality of the studies by analysing some questions as per the study design. Different checklists are developed for different studies.

Short term and long term results

Short term results

- To reduce the size of pneumatised turbinate by minimal surgical morbidity
- To provide minimal mucosal injury or problem
- To provide a safe, effective, and conservative procedure

Long term results

- To minimize recurrence of problem in the future
- To preserve physiological and anatomical functions of the middle turbinate
- To provide stable structure of the lateral nasal wall

2.11 Ethics

This Systematic review focused on the studies related to the management of concha bullosa and completed all the ethical norms. All the studies included in the systematic review do not have any ethical problem.

CHAPTER-4

FINDINGS

Literature Search and Selection:

The literature search yielded few studies as the search was limited to the management of concha bullosa. However, many studies are published on concha bullosa and its surgical management, but none of them explained the effectiveness and efficiency of the surgical techniques used for concha bullosa. Additionally, there are only a few studies that specifically investigated surgical management of concha bullosa. Most studies have reported only surgical techniques for concha bullosa, and this could be the reason identified for the low number of search results. Upon applying the exclusion criteria described in table 2, 12 studies were considered for appraisal, through which 7 studies were measured of high quality (low risk of bias).

Effectiveness of surgery for concha bullosa

Vincent et al. (2010) investigated the relation of concha bullosa and deviated nasal septum (DNS) with chronic rhinosinusitis (CRS) and effectiveness of functional endoscopic sinus surgery (FESS) in the treatment process. Chronic rhinosinusitis is a prevalent disease and the main reason for morbidity in many patients. Functional endoscopic sinus surgery is considered as an effective treatment measure for chronic rhinosinusitis. The study has retrospectively reviewed the recordes of 137 patients', who had treated with FESS from March 2002 to October 2006 in Malaysia. The study revealed that concha bullosa and deviated nasal septum were two general anatomical variations in the nasal cavity. The study also found that concha bullosa was statistically more common in females and in the Indian and Chinese ethnic groups. The study has

found functional endoscopic sinus surgery is highly effective in the treatment of concha bullosa.

Mehta et al. (2017) evaluated the effectiveness and assessed the clinical advantages of endoscopic turbinoplasty technique in concha bullosa. Concha bullosa is an anatomical variation in the nasal cavity which is responsible for headache. Wrongly managed rhinogenic origin of the concha bullosa is a main cause of the headache and can be treated by surgical or medical intervention. The study selected 30 patients for a period of one year who has moderate/mild DNS and related concha bullosa with symptoms such as headache, facial pain, anosmia, nasal obstruction, and recurrent rhinitis. The surgical management and symptoms assessment were performed by the use of VAS. The result of the study revealed that the symptoms of facial pain, headache, nasal obstruction, anosmia with concha bullosa were significantly managed by endoscopic turbinoplasty. The study supported that the endoscopic turbinoplasty is an efficacious and safe procedure for treating concha bullosa. The study also supported that concha bullosa is responsible for the rhinogenic origin of facial pain and headache.

Metha et al. (2013) conducted a study to evaluate the long-term results of endoscopic turbinoplasty surgical technique for concha bullosa. The study selected 36 patients with chronic or recurrent sinusitis, who earlier had concha bullosa with the mucosal disease in CT scan and surgically operated through turbinoplasty with functional endoscopic sinus surgery. All the patients were followed regularly for 7 years to evaluate long tern complications of the surgery. The results of the surgery revealed that there were no immediate or long term complications of the surgery. Only 5 per cent had synechia between the septum and middle turbinate and only one per cent had adhesions between the middle turbinate and lateral wall. The study concluded that endoscopic turbinoplasty

is an effective and safe procedure and preserves middle turbinate physiologically and anatomically with negligible complications.

Belli et al. (2009) investigated the frequency and the endoscopic treatment of the middle turbinate pneumatization or concha bullosa. The study used 49 patients in which 26 were males, and 23 were females with the symptoms of sinusitis and headache. Selected patients participated in the axial and coronal computed tomographic scans of the paranasal sinuses and endoacopic examination between Jan 2005 to July 2007 were included in the study. Functional endoscopic sinus surgery was performed on these patients. The analysis of the study revealed that all the patients have a complaint of chronic nasal obstruction. The patients developed unilateral or a bilateral middle turbinate pneumatization. The patients did not complaint any about any major complication after the endoscopic surgery.

Yan et al. (2014) assessed the effectiveness of biodegradable nasal packing for improving postoperative symptoms and mucosal healing after endoscopic sino-nasal surgery in comparison with conventional/non-packing groups. The study only included randomized controlled trials (RCTs) to compare biodegradable packing with conventional packing that reported postoperative symptoms and mucosal healing results. The study analyzed that biodegradable nasal packing is statistically better than conventional packing with the help of limited available resources.

Comparison of different surgical techniques for concha bullosa

Hanci et al. (2018) compare three techniques to manage concha bullosa on nasal and olfactory functions. The study was conducted to evaluate the most effective technique for the management of concha bullosa for improving nasal and olfactory functions. A prospective, randomized controlled trial was conducted on 95 patients, divided randomly

into three groups; medial laminectomy, lateral laminectomy, and crushing of the middle turbinate. All the patients were analyzed before the operation, and after the operation with the use of Sino-nasal outcome test-22 (SNOT-22), visual analogue score (VRS), peak inspiratory flow (PNIF), and Sniffin stick extended test. The outcomes of the study reflected that all groups demonstrated improvement in nasal and olfactory functions after the surgical management of concha bullosa. However, medial laminectomy gives better improvement then lateral laminectomy and crushing of the middle turbinate were not very effective. The study was also observed a significant improvement in odour differentiation in medial laminectomy group then crushing of middle turbinate. The study recommended medial laminectomy surgical technique for the management of concha bullosa. However, all the three techniques provide improvement in nasal and olfactory functions.

Semih et al. (2018) compared different techniques used for the reduction of concha bullosa. The study was a structured review developed with the help of online databases such as PubMed, Embase, Conchran database of systemic reviews, and Cochran central register of controlled trials. The study found that a variety of surgical techniques were used to deal with symptomatic concha bullosa. The review supported that lateral laminectomy of the middle turbinate is the most desired surgical technique for concha bullosa. The study also suggested a need to compare and objectively evaluated studies on surgical techniques for a larger population.

Effectiveness of surgical management over medical interventions

Yarmohammadi et al. (2012) investigated the superiority level of surgical or medical intervention for the treatment of the rhinogenic origin of headache. The study was a randomized, double blind clinical trial that included 44 patients out of which 19 patients

were male, and 25 patients were females. All the patients were divided into two groups; surgical and medical intervention randomly. The surgical group received turbinoplasty with functional endoscopic sinus surgery approach. Medical invention group followed 3 courses of medicines for 1.5 months. Duration per hour, per week frequency and severities, were analyzed by visual analogue scale (VAS) before the treatment and after the treatment on the interval of 1.5 months, 3 months, and 6 months. The outcomes of the study showed that Turbinoplasty is a simple and acceptable procedure for reducing pain in rhinogenic headaches due to concha bullosa in comparison with medical treatment.

Cantone et al. (2015) evaluated the impact of surgical or medical care on the quality of life of patients with concha bullosa related headache. Clinical studies have shown that there is a close conncetion between mucosal contacts, concha bullosa and rhinogenic headache with quality of life. The study selected 102 patients suffering from concha bullosa and related headache and divided into two group's medical or surgical randomly. The study used a visual analogue scale and the migraine disability score before and after the treatment. The results demonstrated that the severity of the headache and discomfort was decreased in the surgical group in comparison to the medical group. Improvement in symptoms and quality of life showed that the endoscopic surgical technique might provide a speedy resolution of concha bullosa related headache and also reduces health care expenses.

Surgical management of concha bullosa

Badran et al. (2011) study the benefits of surgery in various kinds of isolated concha bullosa. The study was a prospective case series in which 47 patients with nasal congestion, blockage, headache and facial pain having concha bullosa. The kinds of concha bullosa were different in these patients and were classified as bulbous, lamellar,

and extensive concha bullosa. All these concha bullosa were operated with endoscopic surgery. The study revealed that the surgery has a great value in relieving the sinonasal symptoms in patients with concha bullosa.

Kucybata et al. (2017) investigated that the presence of concha bullosa and nasal septal deviation was connected with the development of sinuses and the incidence of inflammation in them. The study retrospectively analysed 214 patients who go through with paranasal sinus computed tomography. The study selected 89 males and 125 females for the study. The study results revealed that only bilateral concha bullosa affects maxillary sinus volumes and nasal septal deviation has an effect on the maxillary sinusitis development in comparison to concha bullosa.

Mariano et al. (2018) investigated that the middle turbinectomy has any effect on the olfaction sense with the use of UPSIT as an assessment tool. A prospective study was performed on 27 patients from 2013 to 2015 who were treated with middle turbinectomy and tested with the UPSIT pre and post-surgery assessment tool with 3 months minimum interval. The study did not found any clinical effect on olfaction sense due to partial middle turbinectomy.

CHAPTER-5

DISCUSSION

Presently, there are various approaches available for the surgical management of concha bullosa that includes total resection, medial or lateral partial resection, crushing or crushing with intrinsic stripping, endoscopic sinus surgery, and turbinoplasty but there is no clear consent for the best available surgical management technique yet.

Surgical management of concha bullosa is recommended when concha bullosa is contributing to the development of patient disease or symptoms. The objective of the surgery is to eliminate the pathology occurred due to the enlarged middle turbinate and to improve the nasal obstruction in the cases of extremely large concha bullosa (Yarmohammadi et al., 2012). Although concha bullosa surgery was conducted for the treatment of rhinogenic headache. However, very limited information on this concept are available due to therapeutic and diagnostic problems. Mostly, concha bullosa surgery was performed with functional endoscopic sinus surgery and septoplasty.

Surgical Techniques

Total middle turbinectomy was not used only for concha bullosa. Pirsig et al. (1972) and Huizing (1988) were first described medial excision of the concha bullosa by eliminating only the medial lamella of the middle turbinate. According to Canon et al. (1994), functional endoscopic sinus surgery was the best surgical technique in treating nasal obstruction without sinus disease. This technique nasal packing only while performing concomitant septal surgery. The functional outcomes of medial and lateral turbinectomy were compared by Kumral et al. (2015) and did not show any significant difference. The study evaluated the patient's postoperative synechia and olfactory functions. Medial excision of concha bullosa prevents the development of frontal sinusitis by inhibiting the

frontal recess synechia formation. The most used technique for treating isolated concha bullosa was lateral excision of the middle turbinate. In this technique, concha bullosa drained the frontal sinus recess. Barun and Stammberger (2003) reconmmanded lateral excision of concha bullosa and crushing if essentially required than medial excision as middle turbinate is medially jointed with the skull base and medial excision destabilized the middle turbinate. Ostium and own mucociliary transport was observed in all types of concha bulloda that included in the resection of the lateral lamella and performed circular transport of the mucus. Canon et al. (1994) applied this technique as a lateral excision technique was excellent in facilitating drainage from the frontal sinus recess into the middle meatus. This technique has a disadvantage of risk of forming synechia when FESS was performed. In the isolated concha bullosa reduction surgery, the rate of synechia was very low while Canon et al. (1994) and Kumral et al. (2015) did not observe synechia, Dogru et al. (2001) reported 27 per cent of synechia. Har-el and Slavit (1996) four year follow-up study was focused on preventing the synechia formation with a rate of 6.9 per cent by removing only medial lamella of the concha bullosa. Singston et al. (2004) used a similar technique by preserving posteroinferior pedicles flap and reduces adhesion. Likewise, Dogru et al. (2001) compared turbinoplasty and lateral turbinectomy by superiorly and inferiorly cutting the concha bullosa with the guidelines of modified Her-el and Slavit technique. This allowed the lamella to adhere evenly and prevent the formation of mucocele.

The transverse excision of the turbinate was the least used technique. Canon et al. have reported this technique only for middle turbinate that attached with skull base by a narrow pedicle. The study did not found any study that described the use of transverse excision of concha bullosa. Choby et al. (2014) did not find any significant difference between the total resection of middle turbinate and partial resection of the middle

turbinate in their systematic meta-analysis on the clinical effects of middle turbinate resection. Studies that supported middle turbinate resection described that this technique improved sinus outflow tract patency and decreased the post-operative formation of synechia. Middle turbinate resection allowed better intra-operative and post-operative visualization of para-nasal sinuses (Lee et al., 2006). Several studies have also reported that olfactory dysfunction was less come across with the crushing techniques in comparison to other techniques. However, treatment of large concha bullosa requires partial resection, so the crushing technique was not applied here.

Kunachak et al. (2002) suggested the middle turbinate lateralization as an effective and safe technique to reduce the symptoms of rhinologic cephalgia developed between the middle turbinate and the nasal septum and induced by the contact point. The study supported that surgical techniques are more safe and effective for concha bullosa.

Eren et al. (2014) compared crush technique with crushing with intrinsic stripping and revealed faces of conchae were completely adhered to each other and allowed togetherness of two mucosal surfaces due to excision of the inner lamella. Metha et al. (2013) also investigated a similar technique by eliminating bony lamella and preserving middle turbinate mucosa. This technique outcomes were quicker and avoided postoperative crushing, but this technique is more time consuming and manipulative in comparison to the other techniques. According to Bansal et al. (2000), sinus CT before computer assisted functional endoscopic sinus surgery (C-A-FESS) supported the surgeon to plan preoperative surgery and avoid complications during the operation. Gunbey (2015) also supported to perform preoperative para-nasal sinus CTs in patients with chronic sinusitis undergoing septoplasty.

Various studies reported about 15-54% frequency of concha bullosa. Calhoun et al. (1991) observed that people with symptoms of sinus disease have a greater incidence of concha bullosa. A study by Lloyd (1990) has shown that concha bullosa was related to increased infection in the sinuses. It has also been predicted that the pneumatized middle turbinate has an imperative role in the pathogen of sinusitis and nasal obstruction. Hanci et al. (2018) were documented that around 86% (26 out of 30) patients are having chronic rhino sinusitis related to unilateral or bilateral concha bullosa. The improvement in the patients was also statistically significant.

Parsons (1998) conducted a retrospective review study on children and adults, treated with surgical technique and found significant improvement in their condition. The headaches in patients were occurred due to large uncinated process, large middle concha, double middle turbinate and nasal spur. The study used the directive endoscopic procedure as a surgical intervention. Havas and Lowinger (2009) predicted slightly smell outcome benefit by treating middle turbinate resection on patients with concha bullosa.

The management of concha bullosa has been described by various techniques. Cannon et al. (1994) favoured lateral excision of the middle turbinate whereas Barun and Stammberger had preferred removal of the lateral lamella. Endoscopic removal of the lateral lamella is a straight forward technique and can be performed with septal or FESS procedures. The procedure also did not show any significant complications. Endoscopic removal of lateral lamella also did not show any synechial formation between the turbinate raw surface and the sinus or septal site.

The endoscopic turbinoplasty is also considered as a safe and efficient procedure for treating concha bullosa because it anatomically and physiologically preserves middle turbinate and treats concha bullosa with slight complications. Concha bullosa

prominently causes a headache of rhinogenic origin and facial pain. Endoscopic turbinoplasty proved as an effective treatment option for this kind of headaches and facial pain.

Long term effect of surgical treatment

Many studies have shown that turbinoplasty is a simple and acceptable procedure in patients with concha bullosa that effectively and efficiently relieve from the pain of rhinogenic headaches.

Ramadam et al. (1999) observed 23 patients with concha bullosa, hypertrophic concha and mucosal contact points. 15 patients were treated with surgical intervention, and 8 patients were treated with medical intervention. The outcomes observed after one year showed that 60 % patient undergone with surgical intervention reported major relief in their headaches in comparison to patients who received medical interventions in the long term. However, patients had hyperthrophic concha, and middle concha bullosa and compared groups were not equal. A study by Giacomini et al. (2003) observed that contact point headache on 34 patients did not respond to the medical therapy but when analysed by VAS after rhinoseptoplasty, septoplasty, and middle turbinate electro-cauterization showed 25 % improvement in the condition. The analysis was conducted after one year of surgery and found superior surgical results in the same group. Mohebbi et al. (2009) study on 36 patients with severe headaches had not responded previously to conventional treatment options, and the intensity of the headache was analysed pre- and post-operatively by utilizing the VAS. The study observed around 83% success in the occurrence of headache after surgery. Mariotti et al. (2009) revealed that endoscopic sinus surgery was widely successful in patients with rhinogenic headache. The study recorded 85% improvement in patients.

The crushing technique is an easy and conservative technique and performed with the help of several instruments, but it has also reported a recurrence of the problem. A prospective study by Tanyeri et al. (2012) investigate adults with concha bullosa and have not found any recurrence of concha bullosa pneumatization. Short term follow-up studies have not shown any recurrence, but long term follow-up of the crushing technique have reported a recurrence of middle concha pneumatisation. Kieff and Busaba (2009) also reported a recurrence of concha bullosa after crushing technique. However, most studies have reported only re-pneumatization of the concha bullosa, not any other symptoms. On the other side, Kocak et al. (2016) applied the crushing technique to around 95 cases of concha bullosa and followed them for two years but have not found any case of reformation.

Effectiveness of surgical management over medical interventions

Yarmohammadi et al. (2012) have proved the effectiveness of turbinoplasty in the management of concha bullosa, which provides relief in the pain due to rhonogenic headaches. The middle turbinate refracting the inspired air to the olfactory epithelium and covers the nasal septum upper portion and the superior and middle turbinates. Apuhan et al. (2013) observed the nerve tissue in the medial part of concha due to olfactory marker staining and suggested the medial part opening of the middle concha in turbinectomy. Apuhan et al. also found olfactory nerve tissue in the medial part of concha bullosa and therefore, suggested the opening of the medial part of the concha bullosa during concha bullosa surgery. However, in the case of concha bullosa with chronic sinusitis, obstruction of the middle meatus from concha bullosa is the main issue. To solve the issue, the lateral lamella of the concha bullosa has been choosen to open. Lateral lamella of the concha bullosa may perhaps forgo in this situation.

Limitation of the Study

The study has several limitations. It was based on already published studies, and the outcome is based on reviewed studies outcomes. The study has not discussed all the anatomical variants of concha bullosa. Therefore, an examination of certain anatomical variants was missed. As the study was based on already published studies. The patient data, data analysis, and data collection were depended only on provided documentation which is subject to bias by the previous assessor.

The study did not quantitatively measure smell quality due to the surgical intervention of concha bullosa, and also the study did not found any significant complications such as orbital complications, epistaxis, atrophic rhinitis or chronic crusting, encountered by extensive middle turbinate resections.

Conclusion

The study discusses the surgical management of concha bullosa and its short term and long term effect. The development of diagnostic tools has made a surgical intervention for concha bullosa easier and positive than it was before. However, there is no clarity about the criteria for surgical management of concha bullosa, and also there are not many studies that objectively evaluated or performed long-term follow-up to compare the surgical procedure of concha bullosa. The surgeon and patient experience with the technique decided preference of surgical technique for the management of concha bullosa. Surgical techniques are highly effective in improving the quality of life, less obstruction and better nasal functions (Javadrashid et al., 2014).

Many surgical techniques are used in the management of concha bullosa, but studies suggest that endoscopic sinus surgery and turbinoplasty are mostly used and acceptable techniques.

Endoscopic turbinoplasty is a simple and effective technique when used with mucous membrane preservation for the treatment of concha bullosa. It also provided easy access to the osteomeatal complex, no trauma, anatomically and physiologically normal middle turbinate, and very less amount of bleeding. It also provides quick healing and avoids postoperative crusting and morbidity, although medial or lateral laminectomy and crushing of the middle turbinate are also used for the treatment but not much successful. Many surgeons prefer lateral laminectomy of the middle turbinate as modified techniques of lateral excision of middle turbinate can reduce the rate of synechia. The crushing technique of concha bullosa is highly effective when used with traumatizing instruments in the treatment of non-extensive types of concha bullosa. All the techniques have their own benefits and disadvantages. The selection of the surgical technique depends on the patients' needs and future requirements.

Recommendations

In future, there is a requirement of objective evaluation of comparison studies on a larger population and a need for long-term evaluation of surgical techniques on patients for concha bullosa.

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Tables

Table 2- Summary of Studies Characteristics

Sr. No	Reference	Aim	Country	Method	Sample Size	Intervention/ surgery Type	Key Findings
1	Semih Karaketir, M.D., Yavuz Uyar, M.D. and Tolgar Lütfi Kumral, M.D., 2018. Surgıcal Techniques for the Treatment of Concha Bullosa: A Systematic Review.	The aim of this article is to review the literature and compare different techniques used for concha bullosa reduction.	Turkey	Structured review article	N=16 articles	turbinoplasty, partial middle turbinectomy and pneumatized middle turbinate	The most preferred technique is a lateral laminectomy of the middle turbinate. A study of a larger population and evaluate and compare existing studies is required.
2	Hanci, D. and	To evaluate the most	Turkey	Prospective,	N= 95	medial	The study recommended

	Altun, H., 2018. Comparison of Three Techniques for the Management of Concha Bullosa on Nasal and Olfactory Functions. *International Journal of Otorhinolaryngology*, *4*(2), p.39.	effective technique for the management of Concha bullosa in terms of improvement in nasal and olfactory functions.		randomized controlled trial.	Three groups Group 1-31 Group 2=32 Group 3= 32	laminectomy, lateral laminectomy, and crushing of the middle turbinate	medial laminectomy surgical technique for the management of concha bullosa. However, all the three techniques provide improvement in nasal and olfactory functions.
3	Mehta, K.S., Yousuf, A., Wazir, I.A. and Sideeq, K., 2017. Clinical benefits of surgical management of concha bullosa. *International Journal of Otorhinolaryngology and Head and Neck Surgery*, *3*(4), p.1.	To evaluate the efficacy and assess the clinical benefits outcome results of our endoscopic turbinoplasty technique for Concha Bullosa.	India	Prospective Study Visual analogue scale	N=30	Endoscopic turbinoplasty technique	The endoscopic turbinoplasty is an efficacious and safe procedure for treating concha bullosa. Concha bullosa is responsible for the rhinogenic origin of facial pain and headache.
4	Cantone, E., Castagna, G., Ferranti, I., Cimmino, M., Sicignano, S., Rega, F., Di Rubbo, V. and Iengo, M., 2015. Concha bullosa related headache disability. *Eur Rev Med Pharmacol Sci*, *19*(13), pp.2327-30.	Aim of the present study is to evaluate the impact of medical or surgical care on the QoL of patients suffering from concha bullosa related headache from the patients' perspective.	Italy	Prospective Study QoL using visual analogue scale (VAS) and, the migraine disability score (MIDAS)	N=102	Medical or surgical treatment	After treatment, the severity of the headache and discomfort decreased in the surgical group compared with the medical group. The improvement of symptoms and QoL recommends that the endoscopic surgical plastic may promote the rapid resolution of concha bullosa related headache and improving the health.
5	Mehta, R. and Kaluskar, S.K., 2011. Endoscopic turbinoplasty of concha bullosa: long term results. *Indian*	The aim of this study is to assess the long-term results of our endoscopic turbinoplasty technique for concha bullosa.	UK	Observational study	N=36	Endoscopic turbinoplasty technique	Endoscopic turbinoplasty is an effective and safe procedure and preserves middle turbinate physiologically and anatomically with negligible complications.

	Journal of Otolaryngology and Head & Neck Surgery, *65*(2), pp.251-254.						
6	Mariano, F.C., Hamerschmidt, R., Soares, C.M.C. and Moreira, A.T., 2018. The Middle Turbinate Resection and Its Repercussion in Olfaction with the University of Pennsylvania Smell Identification Test (UPSIT). *International archives of otorhinolaryngology*, *22*(03), pp.280-283.	To evaluate if the middle turbinectomy has any repercussion on the sense of olfaction by using the UPSIT as an assessment tool.	Brazil	Prospective Study using The University of Pennsylvania smell identification test (UPSIT) tool	N=27	Surgical excision	The study did not show any statistical correlation between the middle turbinectomy and the UPSIT score or between gender and the UPSIT score.
7	Belli, E., Rendine, G. and Mazzone, N., 2009. Concha bullosa: endoscopic treatment. *Journal of Craniofacial Surgery*, *20*(4), pp.1165-1168.	To assess the frequency and the endoscopic treatment of the middle turbinate pneumatization or concha bullosa.	Italy	Prospective Study	N=49 Male=26 Female=23	Functional endoscopic sinus surgery	All the patients showed complaints of chronic nasal obstruction, but there were no serious complications.
8	Yarmohammadi, M.E., Ghasemi, H., Pourfarzam, S., Nadoushan, M.R.J. and Majd, S.A., 2012. Effect of turbinoplasty in concha bullosa induced rhinogenic headache, a	Rhinogenic origin is an important source for headache, which may be treated by the medical or endoscopic intervention. An aim of this study was to clarify whether the surgical or medical intervention is superior	Iran	Randomized double blind clinical trial	N=44 Male=19 Female=25	Group 1= medical intervention (puff fluticasion nasal spray and oral pseudoephedrin) Group 2= turbinoplasty with functional endoscopic sinus surgery	Turbinoplasty in choncha bullusa patients is a simple and acceptable procedure in rhinogenic headaches for relieving pain compared with medical treatment.

	randomized clinical trial. *Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences*, *17*(3), p.229.					approach	
9	Vincent, T.E. and Gendeh, B.S., 2010. The association of concha bullosa and deviated nasal septum with chronic rhinosinusitis in functional endoscopic sinus surgery patients. *Med J Malaysia*, *65*(2), pp.108-11.	The association of concha bullosa and deviated nasal septum with CRS patients requiring FESS amongst the diversified multiethnic Malaysian race.	Malaysia	Retrospective anfalysis	N=137	Functional Endoscopic sinus surgery	The study revealed that concha bullosa and deviated nasal septum were two general anatomical variations in the nasal cavity. The study also found that concha bullosa was statistically more common in females and in the Indian and Chinese ethnic groups. Functional endoscopic sinus surgery is highly effective in the treatment of concha bullosa.
10	Kucybała, I., Janik, K.A., Ciuk, S., Storman, D. and Urbanik, A., 2017. Nasal Septal Deviation and Concha Bullosa–Do They Have an Impact on Maxillary Sinus Volumes and Prevalence of Maxillary Sinusitis?. *Polish journal of radiology*, *82*, p.126.	The aim of the study was to assess if the presence of nasal septal deviation and concha bullosa is connected with the development of sinuses and the incidence of inflammation within them.	Poland	Retrospective study	N=214 Male=89 Female=125	paranasal sinus computed tomography	Nasal septal deviation, associated with concha bullosa, has an effect on the progress of maxillary sinusitis.
11	Badran, H.S., 2011. Role of surgery in isolated concha bullosa. *Clinical Medicine Insights: Ear,*	To study the benefit of surgery in different types of isolated concha bullosa	Egypt	Prospective case series	N=47	Endoscopic operation	The operative management has a great influence in relieving the sinonasal symptoms in patients having isolated Concha bullosa. It is also required a proper selection of patients.

	Nose and Throat, 4, pp.CMENT-S6769. .						
12	Yan, M., Zheng, D., Li, Y., Zheng, Q., Chen, J. and Yang, B., 2014. Biodegradable nasal packings for endoscopic sinonasal surgery: a systematic review and meta-analysis. *PloS one*, *9*(12), p.e115458.	To assess biodegradable nasal packing effectiveness for improving postoperative symptoms and mucosal healing after endoscopic sinonasal surgery as compared with conventional/non-packing groups.	China	Review article	N=19 studies	Endoscopic sino-nasal surgery compared with conventional/ non-packing groups.	Biodegradable nasal packings are statistically better than conventional packings in postoperative symptoms.

Table- 3- Studies that use Qualitative Analysis

Sr. No	**CHECK LIST**	Vincent et al. (2010)	Mehta et al. (2017)	Belli et al. (2009)	Metha et al. (2013)	Yan et al. (2014)	Hanci et al. (2018)	Semih et al. (2018)	Yarmohammadi et al. (2012)	Canton e et al. (2015)	Badran et al. (2011)	Kucybata et al. (2017)	Mariano et al. (2018)
1	Was there a clear statement of the aims of the	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

	research?												
2	Is a qualitative methodology appropriate?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	Was the research design appropriate to address the aims of the research?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	Was the recruitment strategy appropriate to the aims of the research?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	Was the data collected in a way that addressed the research issue?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	Have ethical issues been taken into consideration?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7.	Was the data analysis sufficiently rigorous?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8.	Is there a clear statement of findings?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9.	How valuable is the research?	Highly	Highly	Highly	Highly	Highly	Highly	Highly	Highly	Highly	Highly	Highly	High ly