Effectiveness of endoscopic versus external surgical approaches in the treatment of orbital complications of rhinosinusitis: a systematic review and meta-analysis

Dr Vimal Sekhar MBBS

Master of Clinical Science

Joanna Briggs Institute

Faculty of Health and Medical Sciences

The University of Adelaide

Australia

13th January 2020

Contents

Figures and tables

Thesis declaration

I, Vimal Sekhar, certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of The University of Adelaide and, where applicable, any partner institution responsible for the joint-award of this degree.

I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

I acknowledge that copyright of published works contained within this thesis resides with the copyright holder(s) of those works.

I also give permission for the digital version of my thesis to be made available on the web via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

I acknowledge the support I have received for my research through the provision of an Australian Government Research Training Program Scholarship.

Dr Vimal Sekhar

13th January 2020

Abstract

Objective: This review aims to investigate and compare the effectiveness of endoscopic drainage techniques against external drainage techniques for the treatment of orbital abscesses, subperiosteal abscesses and cavernous sinus thrombosis as a complication of rhinosinusitis.

Introduction: Transnasal endoscopic drainage and external drainage techniques have been used in the management of subperiosteal orbital abscesses secondary to rhinosinusitis. Each of these approaches has its own advantages and disadvantages, with extensive literature describing each technique separately. However, there is a lack of guidance in the studies on assessing and comparing the safety, effectiveness and suitability of these techniques. This review aims to compare the effectiveness of these techniques based on outcome measures in the literature such as: length of postoperative hospital stay, rate of revision surgery and complication rates.

Inclusion criteria: Eligible studies included people of all ages diagnosed with subperiosteal abscess, orbital abscess or cavernous sinus thrombosis (Chandler stages III–V) secondary to rhinosinusitis disease, who have also undergone drainage via either an endoscopic approach, an external approach or a combined surgical approach.

Methods: A comprehensive search of both published and unpublished literature was performed to uncover studies meeting the inclusion criteria. Reference lists of studies included in final analyses were also manually searched. Two reviewers screened studies and a third reviewer was engaged to resolve any disagreements. Studies were, where possible, pooled in statistical meta-analysis, with heterogeneity of data being assessed using the standard Chi-squared and I2 tests.

Results: This review identified nine studies (of limited quality) assessing either endoscopic, external or combined surgical drainage techniques for subperiosteal orbital abscesses. Each of these techniques encompassed a wide variety of surgical approaches, with some variation. Recurrence rates were lower in the combined drainage group, with comparative meta-analysis with external drainage not indicating a statistically significant higher risk of recurrence with external drainage (RR 0.25, 95% CI 0.05-1.29 p = 0.10). Single group analysis of recurrence showed that the overall rate of recurrence was much lower in the combined group (4%, 95% CI 0.08-17.12) in comparison with the external (24%, 95% CI 11-40) or endoscopic groups (26%, 95% CI 10-45). Analysis of total hospitalisation revealed endoscopic drainage was associated with longer total hospitalisation than external drainage, although this difference was not significant (mean difference 0.10 days, 95% CI -4.76 to 4.96 p=0.97). Combined drainage was associated with a slightly longer total hospitalisation than external drainage (mean difference 0.94 days, 95% CI -0.79 to 2.67 p = 0.29). Combined drainage was associated with a longer total hospitalisation than endoscopic drainage (mean difference -0.70 days, 95% CI -3.48 to 2.07 p = 0.62). Post-operative stay analysis revealed longer post-operative stay in the external drainage group when compared to the combined drainage group (mean difference -0.16 days, 95% CI -1.15-0.83 p = 0.76).

Conclusion: Imminent treatment of subperiosteal orbital abscesses via medical and surgical treatment methods is vital, given the high morbidity associated with the disease. This review identified nine studies (of limited quality) assessing either endoscopic, external or combined surgical drainage techniques for subperiosteal orbital abscesses. Each of these techniques encompassed a wide variety of surgical approaches with some variation. All drainage strategies have acceptable outcomes in relation to recurrence rates, total hospitalisation (days), post-operative stay (days) and

complication rate. It is important to clinically identify the presence of subperiosteal orbital abscess, organise for an immediate computed tomography scan of the orbit and sinuses, and commence intravenous antibiotics quickly prior to deciding whether surgery is required or not. This review supports the view that surgeons should choose the appropriate surgical technique based on what they are comfortable and familiar with and what would be the safest option for the patient.

Keywords: endoscopic drainage; external drainage; orbital abscess; orbital complications of sinusitis; subperiosteal abscess

Acknowledgements

The completion of this project was certainly a team effort and as such I would like to thank the following people for their assistance in helping me reach completion.

Vikki Langton for all her assistance with the initial library searches and compilation of a logic grid and search strategy.

Associate Professor Zachary Munn, for his invaluable guidance, supervision, support and motivation especially towards the latter stages of completion.

Dr Isma Iqbal, for her personal support and teaching during my earlier stages of training and constant reminders to keep persisting in completing this task.

Dr Jack Ao, for being my best friend that I've made during my time in Adelaide and for his moral support in critiquing my paper.

Associate Professor Eng Hooi Ooi, for his guidance in assisting me with this project as well as being a conscientious career mentor. Despite having not chosen a career down the ear, nose and throat (ENT) pathway, I thank you for showing interest in me and providing me with opportunities, which I would otherwise not have received. I am forever grateful for what you have done for me.

Ms Caitlin Steffensen, for her support and being one of the closest people I have known, since we first met at JBI. I hope that our mutual support in the course of finishing this project as well as other aspects of life has resulted in as fruitful an endeavour for you as it has for me.

Ms Siew Siang Tay, for undertaking professional copyediting of the thesis in accordance with the Australian Standards for Editing Practice (specifically sections D and E) in a timely manner.

Finally, last not but not least. I would like to thank all of my family including my grandparents, aunties, uncles and cousins. In particular, I would like to thank my mum, dad and sister for sacrificing many things in their lives in order for me to succeed. Everything I have achieved has only been made possible because of your efforts.

1 Introduction

1.1 Context of the review

Orbital complications secondary to rhinosinusitis are a common occurrence with potentially devastating consequences such as vision loss, septicaemia, cavernous sinus thrombosis, intracerebral abscess and death, if left untreated.[1, 2] Treatment of these complications in a timely manner is imperative, with management consisting of commencement of intravenous antibiotics, followed by surgical drainage if a subperiosteal or orbital abscess has been identified.

Traditional drainage techniques consist of an external approach either via a skin or conjunctival incision. Since the advent of endoscopic sinus surgery in 1978[3], more minimally invasive techniques have been introduced in modern practice, with reported benefits including the avoidance of a scar and shorter hospital stay.[4-9]

Modern medical practice has shifted towards a paradigm of increasing endoscopic sinus surgery use for these reasons. Although there is extensive literature describing endoscopic and external techniques separately, there is little literature directly comparing the safety and effectiveness of both techniques for various orbital complications of rhinosinusitis. As a consequence, there is inadequate evidence to inform and support clinicians in deciding which technique is better for different orbital pathologies.

1.1.1 What is rhinosinusitis?

Rhinosinusitis is defined as symptomatic inflammation of the nasal mucosa and paranasal sinuses.[10] Symptoms include nasal obstruction, mucopurulent discharge, facial pressure and fullness, and anosmia.[11, 12] It is a common condition, with a prevalence of 12.6% in the US[13], 10.9% in Europe[14], 8% in China[15] and 8.4% in Australia.[16] It is one of the most common primary care presentations in Australia, with 1.4 in every 100 visits being for management of acute and chronic rhinosinusitis.[17] Since the 1950s, there has been a four-fold decrease in rhinosinusitis complications in developed countries associated with increasing antibiotic treatment.[18] Nonetheless, orbital complications are reported to occur in 5-7% of acute rhinosinusitis patients.[19-21] Orbital complications are ocular emergencies presenting as pre-septal (periorbital) or post-septal (orbital) cellulitis, subperiosteal abscess or orbital abscess.

1.1.2 Anatomy

The paranasal sinuses are air filled spaces surrounding the nasal cavity, comprising the maxillary, ethmoid, frontal and sphenoid sinuses. The ethmoid sinus is most commonly affected by infection, followed by the maxillary, frontal and sphenoid sinuses.[22-26] The medial wall of the ethmoid sinus contains a paper-thin bony wall called the 'lamina papyracea', which separates the ethmoid sinus from the orbit. The orbital septum (palpebral fascia) is a piece of fibrous connective tissue progressing from the orbital bone periosteum that separates the preseptal (eyelid) and postseptal compartment (eyeball and neuromuscular components), thereby acting as a barrier from eyelid infections progressing to the orbit.[27, 28] The periosteum joins to form the septum at the arcus marginalis while the septal extension combines with the inferior portion of the tarsal plate of the lower eyelid, and the levator aponeurosis and superior tarsal plate of the upper lid.[29] The subperiosteal space is a potential space located between the periorbita (periosteum of orbital bone) and the bony orbital wall in which abscesses can develop.[30] It is important to distinguish orbital cellulitis from peri-orbital cellulitis, which is a more common condition affecting the structures anterior to the orbital septum. Swelling in the post-septal region results in an increased intra-orbital pressure, which is associated with compression of the central artery and vein, and the optic nerve.

1.1.3 Pathophysiology

Acute bacterial rhinosinusitis is usually preceded by a viral upper respiratory tract infection that leads to nasal mucosal congestion and ostial obstruction, thereby impairing sinonasal drainage and airflow. There is associated mucociliary transport dysfunction with mucus thickening and stasis, all of which promote concordant bacterial infection. The orbit is susceptible to contiguous spread of infection from the surrounding paranasal sinuses. Congenital or acquired Zuckerhandl dehiscence of the lamina papyracea allows for pathogens to penetrate through to the orbit from the ethmoid sinus.[31] Infection may also traverse through the anterior and posterior ethmoid neurovascular foramina.[31] The valveless orbital venous drainage system allows for both anterograde and retrograde dissemination of bacteria, thereby enabling thrombophlebitis formation.[31] The combination of these factors allows for the propagation of an infectious and inflammatory process through to the orbit, with the medial wall of the orbit being the most common region for orbital abscess and subperiosteal abscess formation.[30] Once there is orbital infection, the disease can spread intracranially to the cavernous sinus and contralateral eye through the cavernous sinus dura mater which is contiguous with the orbital periosteum.[32]

The bacterial spectrum includes *Staphylococcus aureus* (most common in adults[33]), *Streptococci* (most common in children[33]), *Streptococcus pyogenes*, diptheroids, *Escherichia coli*, *Moraxella catarrhalis*, anaerobes (such as bacteriodes, fusobacterium, peptostreptococcus and prevotella) and fungal disease (mucormycosis, aspergillosis). Haemophilus influenza was historically a key pathogen involved in orbital cellulitis[34], however the increasing rates of haemophilus type B vaccination has diminished its presence. In children aged nine years and older, polymicrobial infections are more predominant[35] whilst single gram positive pathogens are more common in younger children.[36, 37] Other causes of orbital cellulitis include periocular trauma or surgery, dental infections, dacryocystitis, endophthalmitis or haematogenous spread.

1.1.4 Clinical features

Orbital complications of acute rhinosinusitis most commonly affect younger children under the age of 10, with orbital cellulitis presenting at a mean age of 7.2 years.[37-40] Children younger than nine years of age tend to develop singular aerobic infections while older children and adolescent patients are more predisposed to polymicrobial infections.[38] One explanation is that in older children there is sinus cavity maturation without the accordant enlargement of the ostia, which fosters anaerobic conditions and promotes sequestration and growth of aerobic and anaerobic pathogens.[37] Identifying clinical features of orbital complications can be challenging, particularly in children where history taking is difficult.[29] Common clinical features include eyelid oedema, conjuctival chemosis, ophthalmoplegia, visual acuity changes, diplopia, painful eye movements, orbital proptosis and globe displacement. Cavernous sinus thrombosis is an uncommon yet devastating intracranial complication that presents with decreased visual acuity bilaterally, cranial nerve III, V, VI palsies, prostration, septicaemia and meningism.[13, 41, 42]

1.1.5 Investigations

Blood examination often reveals a leucocytosis with a neutrophilic predominance.[(43, 44)] Computed tomography (CT) imaging is the radiological imaging of choice as it is widely accessible, has a short imaging time, delineates changes in soft tissues, demonstrates sinusitis, displays bony anatomy detail accurately, and provides high spatial resolution images of retrobulbar and intraconal masses. [1, 27, 45-47] Magnetic resonance imaging (MRI) provides greater soft tissue and vascular detail, and is used to assess for complications such as orbital abscess and cavernous sinus thrombosis.

1.1.6 Classification systems

Various authors such as Hubert and Jain et al. have formed categorisation systems to classify the orbital complications of sinusitis.[31, 48] Chandler's classification[49], which was developed in 1970, is the system most commonly used today and classifies infections based on its anatomical location within the periorbita, sinuses and cranium (see Table 1.01). The categories provide an important indicator of morbidity and mortality, with a progression in severity from pre-septal infection to the deadly cavernous sinus thrombosis.

Table 1.01: Chandler's classification of orbital complications of rhinosinusitis

Stage	**Description**
Type I (inflammatory oedema/preseptal cellulitis)	Eyelid oedema, normal visual acuity, normal ocular movement
Type II (orbital cellulitis)	Widespread oedema of orbital contents, bacterial and inflammatory cell infiltration, normal/decreased visual acuity
Type III (subperiosteal abscess)	Pus collection between orbital bony wall and periorbita, globe displacement
Type IV (orbital abscess)	Pus collection within orbital tissues, decreased visual acuity, proptosis, chemosis, ophthalmoplegia
Type V (cavernous sinus thrombosis)	Inflammatory extension posteriorly to cavernous sinus, cranial nerve palsies, bilateral eye signs.

In Type I, oedema is confined to the eyelid (periorbital or preseptal cellulitis). There is swelling of the eyelid due to a disruption of ethmoid vessel drainage whereby venous congestion is propagated through valveless veins to the eyelid. In Type II (orbital cellulitis), there is widespread invasion by inflammatory cells in the orbital tissues resulting in diffuse orbital oedema, eyelid oedema, conjuctival chemosis, painful eye movement, vision impairment and ocular proptosis. In Type III (subperiosteal abscess), there is a collection of pus peri-orbitally and between the periosteum and orbital bony wall. There is concurrent marked eyelid oedema, tenderness on palpation of the orbital rim, with decreasing ocular motility and visual acuity and worsening ocular proptosis. Type IV (orbital abscess) is classified by the presence of a pus collection inside or outside the muscle cone. It occurs often as a consequence of untreated orbital cellulitis resulting in severe proptosis, conjuctival chemosis, decreased ocular motility and vision loss. Type V (cavernous sinus thrombosis) involves intracranial extension of the infection into the cavernous sinus, with severe bilateral eyelid oedema and deficits of cranial nerves III, V, and VI. There also may be signs of septicaemia and meningism.[41] A rare but severe complication of sinus and orbital infection is orbital apex syndrome whereby sinus disease extends to the optic foramen and superior orbital fissure, causing eyelid oedema, proptosis, ophthalmoplegia, optic neuritis and neuralgia of the ophthalmic division of the trigeminal nerve.[50] For the purposes of this review, when analysing cases of orbital cellulitis, we shall consider cases that are classified within a Chandler III-IV score range.

1.1.7 Management

With the evolution of time and the resultant progression in development of diagnostic instruments, advancement of new broad-spectrum antibiotics and improvement in surgical approaches, the management of orbital cellulitis and its complications has evolved. Patients are commonly hospitalised and a multi-disciplinary approach is often necessary for the management of orbital cellulitis with paediatricians, ophthalmologists, otorhinolaryngologists and infectious disease physicians providing assistance.[51]

1.1.7.1 Medical management

All patients with clinical symptoms fitting in the Chandler's I-V classification system are normally commenced on intravenous antibiotics. The treatment of Chandler I (pre-septal cellulitis) and II (post-septal cellulitis) is solely aligned to medical treatment. This most commonly involves the commencement of intravenous broad-spectrum antibiotics, with additional use of nasal decongestant therapy and intravenous steroids.

A common antibiotic regime for treatment of orbital complications of sinusitis involves the combination of a beta-lactamase resistant penicillin, clindamycin and a third generation cephalosporin such as ceftriaxone.[31] The evolving presence of Methicillin-resistant *Staphylococcus aureus* has also necessitated the use of vancomycin, as appropriate. Concurrent treatment of sinusitis is important when treating the orbital complications associated with it. Nasal saline irrigation and decongestants have been demonstrated to improve sinonasal drainage and subperiosteal abscess treatment outcomes.[52, 53] Corticosteroid use in orbital complications of sinusitis continues to be debated due to the risk of disease progression from immunosuppression. They are associated with a reduction in scarring, inflammatory cytokines and mucosal oedema.[54-58] This is particularly useful for reducing inflammation from bacterial lysis following antibiotic therapy.[59] When used as an antibiotic adjunct, corticosteroids can decrease the incidence of adhesions, sinus swelling and stenosis, thereby improving surgical outcomes for subperiosteal abscesses.[59-61]

1.1.7.2 Surgical management

The majority of orbital infections secondary to sinusitis will resolve with medical management. However, when there is minimal symptom resolution with medical therapy, surgical intervention may be required. There have been various recommendations as to when surgical intervention is necessary. Younis[25] and Harris[37] have suggested various parameters for surgical drainage. They include worsening visual acuity, ophthalmoplegia, severe orbital complications (e.g. blindness, afferent pupillary defect), frank orbital abscess or large subperiosteal abscess formation and lack of clinical improvement within 48 hours of medical management. The management of medial subperiosteal abscesses (Chandler III) remains contentious as to whether surgical drainage is required, particularly in children. Souliere's retrospective case series suggested that subperiosteal abscesses may be managed with 48 hours of antibiotics in the absence of any deteriorating ophthalmological symptoms and signs, intracranial extension or systemic toxicity.[62] Parameters such as proptosis, patient age and abscess size have been suggested as predictors for surgical intervention. Rahbar's[63] multivariate analysis of a retrospective series suggested that proptosis itself is the only indicator for surgery. Oxford's[39] data however suggested the contrary, with 55% of medically treated patients having proptosis greater than 2mm, thereby suggesting that the depth of proptosis might be of relevance. Age is also another conflicting predictor, with several studies suggesting that older children were more likely to undergo surgical drainage due to the increased risk of polymicrobial infections.[36, 37, 52, 64] Oxford's[39] findings however did not find any statistical difference in age between the medically and surgically treated patients in the study. Abscess size is a more consistent predictor for surgery, with both Oxford[39] and Ryan[46] reporting significantly greater abscess width in patients surgically treated compared to medically managed patients. In lieu of the results, Oxford[39] suggested criteria of normal vision, no ophthalmoplegia, intraocular pressure <20mmHg, proptosis ≤ 5mm and abscess width ≤ 4mm as suitable indications for medical therapy.

The surgical techniques aimed at draining subperiosteal or orbital abscesses include an external approach via a skin or conjuctival incision, a transnasal endoscopic approach or a combination of both. The approach taken depends on the skillset of the surgeon, abscess location and extraocular muscle involvement. Tanna et al.'s retrospective case series showed that abscesses involving external drainage were more likely to have involvement of the medial rectus, superior rectus and superior oblique muscles.[65] Several studies have recommended the transnasal endoscopic approach as an appropriate technique for medially positioned abscesses[65-69], whilst superomedial or superior abscesses should be drained via an external approach alone[39, 70], or a combined approach. [66, 71, 72] Superiorly based abscesses can be difficult to access endoscopically due to their anatomical position. As such, there are difficulties in gaining adequate drainage, which predisposes to disease relapse and the need for a second operation.[39, 67, 70, 73-79] Roithmann et al. however described a transnasal endoscopic approach with special care needing to be taken to avoid the anterior ethmoidal artery.[80] External drainage or a combined approach are recommended for abscesses extending laterally towards the roof or floor of the orbit.[81] Some studies have suggested that, irrespective of the location of the abscess, a transnasal endoscopic approach is sufficient in treating the pathology.[4, 66] One study favoured external drainage over an endoscopic approach for abscesses with extraocular involvement.[65]

1.1.7.2.1 External drainage

There are a variety of external skin or conjunctival incisions that may be made dependent on the location of the abscess. Such techniques include the Lynch-Howarth/Modified Lynch Approach and transcaruncular approach for medial abscesses, sub-brow incision for superior abscesses and sub-ciliary incision and subconjunctival approach for inferior abscesses. The traditional approach to drainage of a medial orbital collection is via a Lynch-Howarth or Modified Lynch incision that allows an external ethmoidectomy to be performed under general anaesthesia. Dissection is performed towards the subperiosteal space whereby the abscess is drained and a penrose drain inserted. The advantages of this approach are that it provides the most direct route to the abscess and offers good visualization of the loculations. The incision can also be extended superiorly in the event of frontal sinus involvement or a superior compartment abscess[82]. The disadvantages of this technique are that it necessitates a facial scar, potential webbing, delayed healing and suture abscess.[5, 26, 67, 83, 84]

1.1.7.2.2 Endoscopic drainage

The advent of endoscopic sinus surgery by Messerklinger's cadaveric study in 1978 and the development of techniques by Messerklinger and Stammberger[85] and Lusk [86] have allowed minimally invasive approaches to treat orbital complications of sinusitis. The majority of abscesses treated via a solitary endoscopic approach are located medially and involve drainage of the abscess and contributing infected paranasal sinus. Manning et al.[87] was the first to advocate the use of endoscopic approaches in draining subperiosteal abscesses in children. The procedure is done under general anaesthesia where an endoscopic uncincectomy is performed, followed by widening of the maxillary sinus ostium so as to provide access to drainage of any maxillary sinus disease. Using curettage, the anterior and posterior ethmoid cells are removed and the lamina papyracea is resected to allow for drainage.[5] There are differing views on how much of the lamina papyracea to resect, with many others recommending a conservative endoscopic approach to reduce the risk of post-operative facial skeleton growth retardation.[66, 77, 78, 88] Conversely, an extensive resection of the lamina papyracea is proposed to prevent incomplete drainage and pus re-accumulation.[79] Several advantages to this technique include concurrent drainage of the abscess and infected paranasal sinus, avoidance of a facial scar, inferior morbidity and shorter hospital stay in comparison with external drainage.[4-9] The disadvantages of this approach include medial rectus muscle or optic nerve damage, poor visibility secondary to hyperaemic mucosal bleeding, limited manoeuvrability within small nasal passages and inadequate drainage requiring a second operation.[6, 7, 71, 75, 82, 89-92]

1.2 Systematic reviews and evidence based medicine

Evidence based medicine is defined as the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients.[93]Evidence based medicine relies[94] upon good quality evidence to inform and assist clinicians in treating patients. As the amount of medical research literature continues to propagate, it is important that clinicians are able to properly synthesise and interpret the available data in order to assist with decision-making. The vast array of information available can make this process difficult.

Systematic reviews are a type of secondary research that is composed of an amalgamation of the available studies, with the data analysed, synthesised and presented in a concise manner. Systematic reviews allow for clinicians (or researchers) to pool all the current and past literature in order to highlight deficiencies in the evidence base and provide recommendations for further practice.[95] Systematic reviews follow a methodical process that is transparent and reproducible. A summary of these steps include:

- Protocol development
- Formation of a review question

- Definition of inclusion and exclusion criteria for literature search
- Searching to identify all literature
- Critical appraisal of included studies
- Extracting data from the included studies
- Synthesis of extracted data.
- Reporting and interpreting the results along with any recommendations for practice and research.

This systematic review strictly adhered to JBI methodology that has been founded upon the JBI model of evidence based health care. It follows a practical yet holistic approach in the collection of evidence whilst also focusing on the mantra that the information be synthesised appropriately such that it can be translated into clinical practice. The methodology incorporates the fact that there are varying qualities and designs of studies available in the literature and thus encourages other types of evidence to be included in the systematic review, as appropriate (or inclusion of the best available evidence).[96]

Meta-analysis adds to this by providing a quantified synthesis of pooled data using statistical analysis. A meta-analysis refers to the statistical synthesis of quantitative results from two or more studies and ascertains if included studies are homogenous or heterogenous.[97] This is accomplished through the use of forest plots and tests (I squared, Chi squared) to assess for heterogeneity and homogeneity. Overall, this allows for the combination of data from different studies to determine the overall effect of an intervention. Where meta-analysis is not possible, a narrative synthesis, which describes and summarises the information from multiple studies, is conducted. The narrative synthesis approach in systematic reviews summarises numerical data and statistics in a structured plain text format.[98]

1.3 The purpose of this systematic review

The purpose of this systematic review is to evaluate the effectiveness of external drainage techniques compared to endoscopic drainage techniques in the management of these orbital complications. We aim to identify the best treatment approach with the lowest rate of complications and revision surgery. Transnasal endoscopic drainage is considered to be a safe procedure, with decreased morbidity, improved cosmesis and shorter hospital stay. However, it has also been suggested that it leads to an increased rate of incomplete drainage, requiring a subsequent operation. Although there is extensive literature describing endoscopic or external drainage techniques separately, there is a lack of guidance in these studies in relation to the safety, effectiveness and suitability of each technique for the treatment of various forms of subperiosteal and orbital abscesses. There is also a lack of studies directly comparing the safety and effectiveness of external approaches against endoscopic drainage. Hence, we aim to compare the effectiveness of these techniques in the literature based on measurement of the outcomes of length of post-operative hospital stay, rate of revision surgery and complication rates. We hope the findings from our review may have a clinical impact on the surgical management of orbital complications by reducing hospital costs through decreased hospital stays and operating theatre costs, lower hospital re-presentations, less medical specialists required in the patient's care and avoidance of any cosmetic deformities in young children and adults.

2 Methods and methodology

This chapter presents an outline of the methods used to complete this systematic review. In addition to the review question, the inclusion and exclusion criteria, search strategy and study selection are described, as well as a description of the study selection and critical appraisal processes. The process of data extraction and synthesis using both meta-analysis and narrative description is also presented. The *a priori* protocol is as published in the *JBI Database of Systematic Reviews and Implementation Reports*.[99]

2.1 Review question

The review question is: What is the effectiveness of endoscopic versus external surgical approaches in the treatment of orbital and subperiosteal abscesses as a complication of rhinosinusitis?

The objective of this systematic review is to investigate and compare the effectiveness of endoscopic drainage techniques against external drainage techniques for the treatment of patients with orbital and subperiosteal abscesses as a complication of rhinosinusitis.

More specifically, the objectives are to assess the effectiveness of each technique by evaluating objective measures, which include post-operative length of stay in hospital, total hospitalisation stay, rate of post-surgical complications and recurrence rates.

2.2 Types of participants

The participants included in the review were people of all ages who had a diagnosis of subperiosteal abscess, orbital abscess or cavernous sinus thrombosis (Chandler III-V) secondary to rhinosinusitis disease. This can be with or without the support of computed tomography or magnetic resonance imaging. The participants involved also underwent abscess drainage either via an endoscopic approach, an external approach or a combined surgical approach.

Exclusion criteria included patients with a mucocele or pyocele in the paranasal sinuses, history of active malignancy, history of maxillofacial trauma, previous organ transplantation, cases of orbital abscess and subperiosteal abscess without paranasal sinus disease aetiology, anatomical abnormalities of the orbit or paranasal sinuses, post-traumatic sinusitis, immunosuppressive states and cases of Chandler I and II orbital complications of sinusitis.

2.3 Types of interventions

This review considered studies that evaluated the use of either endoscopic with/without medical therapy and combined drainage (endoscopic + external drainage) with/without medical therapy in the treatment of the orbital complications of rhinosinusitis. The intervention was compared to the traditional technique of external drainage with or without medical therapy.

2.4 Types of outcomes

The primary outcomes of interest were: number of post-operative days in hospital, length of total hospitalisation, rate of recurrence/surgical failure rate and complication rate (e.g. blindness and visual loss, ptosis, surgical damage to orbital structures, haemorrhage, intracranial sepsis, facial scarring, stitch abscess, diplopia and enophthalmos).

2.5 Types of studies

The review considered both experimental and observational study designs including randomized controlled trials, non-randomized controlled trials (such as controlled clinical trials which have used systematic but non-random means of allocation), quasi-experimental studies, case control studies, before and after studies, with prospective and retrospective cohort studies included if they had a sample size of five patients or more. Studies published in English were included. This was done in order to ensure that there was at least some minimal data set available and was an arbitrary cut off. Studies published from 1978 to the present were included.

2.6 Review methods

2.6.1 Search strategy

The systematic review was conducted in accordance with the Joanna Briggs Institute methodology for systematic reviews of effectiveness evidence.[100]

The search strategy aimed to locate both published and unpublished studies. An initial limited search of MEDLINE and CINAHL was undertaken to identify articles on the topic. The text words contained in the titles and abstracts of relevant articles, and the index terms used to describe the articles were used to develop a full search strategy for the MEDLINE (PubMed) database (see Appendix 1). Thomson Reuters Endnote x8 software (Clarivate Analytics, PA, USA) was used to store and read results. The search strategy, including all identified keywords and index terms, was adapted for each included information source. The databases searched included: MEDLINE (PubMed), CINAHL, Embase and Scopus. Grey literature was searched through Cochrane Central Register of Control Trials (CENTRAL) and ProQuest. The reference lists of all studies selected for critical appraisal were screened for additional studies.

The list of databases searched is shown in Table 2.01.

Table 2.01: Databases searched, with dates

Database	**Date**	**Results**
CINAHL	17/02/2019	1131
CENTRAL	17/02/2019	96
Embase	17/02/2019	240
MEDLINE (PubMed)	17/02/2019	456
ProQuest	17/02/2019	26
Scopus	17/02/2019	536
Total	17/02/2019	2485

2.6.2 Study selection

Following the search, all identified citations were collated and uploaded into EndNote x8 (Clarivate Analytics, PA, USA), with duplicates removed. Titles and abstracts were then screened by two independent reviewers (JA, IQ) for assessment against the inclusion criteria for the review. Potentially relevant studies were retrieved in full and their citation details imported into the Joanna Briggs Institute System for the Unified Management, Assessment and Review of Information (JBI SUMARI; The Joanna Briggs Institute, Adelaide, Australia).[101] The full texts of selected studies were retrieved and assessed in detail against the inclusion criteria by two independent reviewers (JA, IQ). Reasons for exclusion of full text studies that did not meet the inclusion criteria were recorded and are reported in this systematic review (see Appendix 3). Any disagreements that arose between the reviewers at each stage of the study selection process were resolved through discussion. The results of the search is presented in a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.[108]

2.6.3 Assessment of methodological quality

Eligible studies were critically appraised by two independent reviewers at the study level for methodological quality using the standardized critical appraisal instruments from the Joanna Briggs Institute for experimental and quasi-experimental studies (see Appendix 2).[102] The instrument consists of 10 'yes/no/unclear' questions on different aspects of the included papers aimed at assessing the quality of the papers and reducing the risk of bias. Authors of papers were contacted to request missing or additional data for clarification, where required. Any disagreements that arose between the reviewers were resolved through discussion. The results of critical appraisal are reported in narrative form and in a table. All studies, regardless of their methodological quality, underwent data extraction and synthesis (where possible).

2.6.4 Data extraction and synthesis

Data was extracted manually from studies included in the review by two independent reviewers using the standardized Joanna Briggs Institute data extraction tool in JBI SUMARI supplemented by Microsoft Excel (Microsoft Excel 2011 for Mac) (Redmond, Washington, USA). The data extracted included specific details about the interventions, populations, study methods and outcomes of significance to the review question and specific objectives. These included length of hospitalization (days), length of post-operative stay (days), complication rate (e.g. blindness and visual loss, ptosis, surgical damage to orbital structures, haemorrhage, intracranial sepsis, facial scarring, stitch abscess, diplopia, enophthalmos) and rate of recurrence. Additional data on age, gender, symptom profile, Chandler's classification of orbital complications of sinusitis, abscess location, rate of revision surgery, microbiology results, revision surgery surgical approach and follow-up (weeks) was collected.

Studies were pooled in statistical meta-analysis using OpenMeta[Analyst][103], Cochrane's RevMan[104] or StatsDirect.[105] For head to head comparisons, RevMan 5.3 software (Copenhagen: The Nordic Cochrane Centre, Cochrane)) was used to perform meta-analysis from comparative study results, where possible. Effect sizes were expressed as relative risk ratios and their 95% confidence intervals (95% CI) were calculated for analysis. Heterogeneity was assessed statistically using the standard Chi-squared and I^2 tests. For single group meta-analysis, OpenMeta[Analyst] 10.12 (Brown University, Providence, RI, USA) and StatsDirect (Cambridge, UK) were used to generate forest plots using weighted means for continuous data and proportional meta-analysis for dichotomous data. Data was transformed using the Freeman-Tukey method in a random effects model using the DerSimonian-Laird approach for proportional meta-analysis.[106,

[107] Final findings are summarised in a GRADE (Grading of Recommendations Assessment, Development and Evaluation) summary of findings tables created using GRADEpro GDT (McMaster University, ON, Canada).

3 Results

3.1 Search results

Figure 3.01 depicts a flowchart of the study selection. A total of 2450 articles were identified from the search of published literature in the pre-selected databases and the search for grey literature. After removal of 734 duplicates, 1716 articles remained for title and abstract screening.

The screening process involved individually viewing the titles and abstracts of the articles and excluding those articles that did not satisfy the inclusion criteria. A total of 1631 articles were excluded upon screening. The remaining 84 articles underwent full-text review, with nine studies being finally included in the systematic review. The main reasons for exclusion were incorrect outcome/s (n = 31), only one or unclear technique described (n = 43) and mucocele/pycocele presence (n = 2) (see Appendix 3).

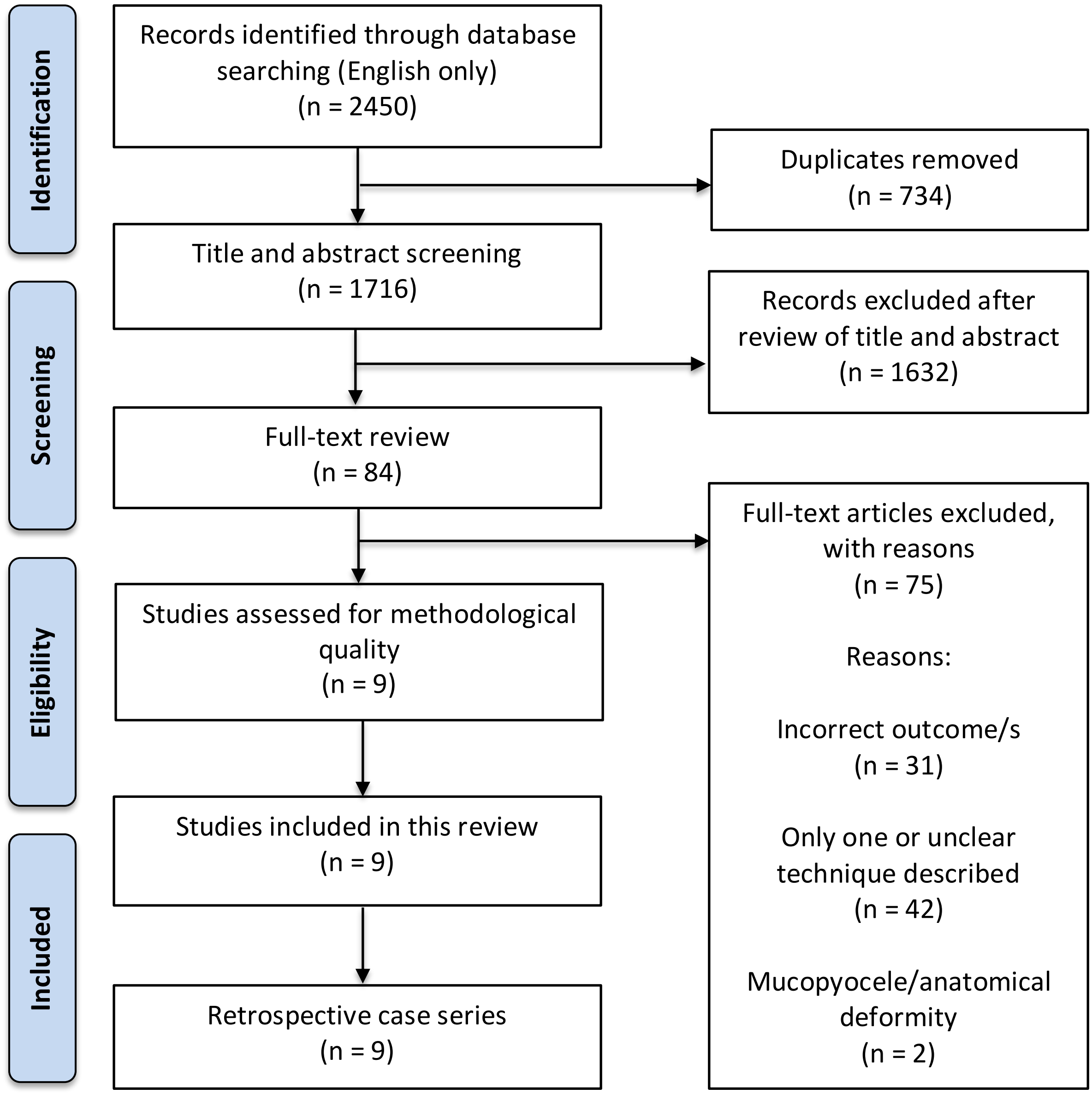

Figure 3.01: PRISMA flow diagram of the study selection and inclusion process[108]

3.2 Description of included studies

Table 3.01 summarises the included studies. Each study is identified (where possible) by study type, research methods, follow-up times, participant demographic, setting and inclusion criteria. The control and comparator groups were stated and compared for the relevant outcome. When provided in the study reports, 95% CIs and p-values were extracted and included in the table with significant p-values in bold. Additional notes have been provided in the last column. The review consists of nine retrospective studies. A total of 145 participants were included in the studies, with an age range between 12 days to 46 years of age. The majority of cases comprised medially located abscesses, with 66 external drainages, 58 endoscopic drainages and 21 combined drainages (see Table 3.01).

Rubin[57, 81] performed a retrospective analysis encompassing all consecutive cases of orbital subperiosteal abscesses complicating paediatric acute ethmoiditis (Chandler III). Abscesses with lateral extension were excluded as the authors felt that the abscesses could not be properly reached via an endoscopic approach. Thirty-eight patients were identified with a follow-up duration of at least two months post-operatively. They compared three groups of patients treated with either external drainage, endoscopic drainage or a combined approach, assessing for treatment outcomes that included duration of hospitalisation, complication rate, surgical failure rate and duration of post-operative stay. External drainage consisted of a 10-mm cutaneous incision at the inner canthus with elevation of the periosteum off the lamina papyracea. A rubber Delbet corrugated rain was left for 48 hours post-operatively through which a povidine-iodine solution could be irrigated through to the infected tissues. Endoscopic drainage entailed using a 30-degree endoscope to perform an ethmoidectomy through opening of the lamina papyracea. The extent to which both the anterior and posterior ethmoid cells were cleared was dependant on the degree of infection and pus identified intra-operatively.

Pelton[109] performed a retrospective analysis of 11 patients who had an acute subperiosteal abscess and sinusitis that were treated with either a transcaruncular approach or combined approach of transcaruncular orbitotomy with endoscopic ethmoidectomy. Any patients treated with other surgical techniques such as open ethmoidectomy were excluded from the study. Outcome measures included judgement of cosmetic appearance by the surgeon and family, resolution of symptoms, length of hospital stay, length of post-operative stay and complication rate. A transcaruncular approach involves a lower eyelid transconjunctival incision that is extended medially around the lacrimal caruncle. In this study, bupivacaine hydrochloride with epinephrine was firstly infiltrated into the lower eyelid and medial canthus. Using tenotomy scissors, an incision was made through the conjunctiva either medial or lateral to the caruncle. A combination of blunt and sharp dissection was then used to access the anterior medial orbital wall in a posterior direction. Once the orbital periosteum was reached, it was incised and elevated along the lamina papyracea until the abscess cavity is reached and irrigated and drained. If there was evidence of any dehiscence of the lamina or any communication of the orbit with the ethmoid cavity, an endoscope was introduced through the orbit into the ethmoid cavity. The incision of the conjunctiva was closed with a single 6-0 plain gut suture. A vessel loop drain was left behind in some cases; it was removed within 24 hours. Endoscopic ethmoidectomy was performed alongside this transcaruncular approach in a combined drainage case.

Rahbar[63] performed a retrospective study of 19 patients with clinical and radiographic evidence of subperiosteal orbital abscess secondary to sinusitis who were either treated with external or endoscopic drainage. All patients received antibiotics (ampicillin sodium and sulbactam sodium, with one patient receiving an oxacillin sodium and cefotaxime combination) and oxymetazoline drops, with five cases excluded as they did not undergo any surgical intervention, thereby leaving 14 cases for analysis. Variables analysed included length of hospitalisation, complication rate and microbiological specimens collected. Ophthalmological examination was performed twice daily. Endoscopic drainage was performed under a general anaesthetic, with the nasal cavity packed with oxymetazoline hydrochloride soaked cotton for several minutes and 0.5% lidocaine with 1:200000 epinephrine used for local anaesthesia. The middle turbinate was medialised prior to an uncincectomy being performed. A maxillary antrostomy and anterior and posterior ethmoidectomy were then completed. Using a freer elevator, the inferior portion of the lamina papyracea was opened, allowing for drainage of the subperiosteal abscess. Isotonic sodium chloride was irrigated through the nasal cavity and a water-soluble antibiotic ointment was applied. External drainage involved an external incision and drainage of the abscess; it was unclear what external approach was used. Patients were followed up for a period of 20 months.

Huang[72] performed a retrospective study of 22 patients with orbital subperiosteal abscess who underwent either endoscopic, external or combined drainage. All participants underwent clinical examination, with either orbital or sinus computed tomographic scans confirming the presence of both subperiosteal abscess and concomitant sinusitis. Abscesses secondary to other causes such as trauma, previous surgery, anatomical deformities, malignancies or immunosuppressive states were excluded. The decision to choose which technique to employ was based on abscess location. Medially located abscesses underwent endoscopic drainage, superiorly located abscesses were drained externally and if an abscess involved both the medial and superior compartments and displayed any lateral extension, then a combined approach was done. External drainage began with a 2-3ml injection of 2% xylocaine and 1:100000 epinephrine into the medial bulbar conjunctiva. Following lid retraction, a transcaruncular incision was conducted using Westcott scissors. Stevens scissors were used to dissect in an anteroposterior fashion towards the medial orbital wall, taking care to prevent any iatrogenic injury to the lacrimal sac. A freer elevator was used to the periorbita whereby the abscess wall was then incised and drained. The transcaruncular incision was closed with continuous 8-0 vicryl transconjunctival sutures. The endoscopic approach involved firstly decongesting the inferior and middle turbinates with 2% oxymetazoline soaked pledgets. Following this, an inferior unincinectomy was performed and the ethmoid air cells were curetted out. The lamina papyracea was incised and removed until all pus was expressed. This was often aided by compressing on the ipsilateral eyelids. Surgicel and Vaseline were used to pack the wound with the dressing removed two days later.

Migirov[67] conducted a comparative non randomised retrospective study of 22 patients who either underwent endoscopic or external drainage for medial subperiosteal abscess. All patients underwent computed tomography on the sinuses and orbit, and had ophthalmological examination before and after surgery. Patients were followed up for a course of at least 24 months with outcomes such as length of hospitalisation and complication rate, compared between the two groups. Endoscopic drainage was performed using a 0 degree endoscope with ethmoidectomy and partial removal of the lamina papyracea. No packing was administered into the wound afterwards. External drainage was done via an external ethmoidectomy.

Dewan[110] conducted a retrospective chart review of all patient admissions for orbital inflammation and orbital cellulitis. Cases secondary to non-infectious causes or infective causes other than sinus related were excluded. Twenty-three cases of patients having orbital subperiosteal abscess were identified, with 15 cases undergoing surgical drainage (external or combined therapy). Outcomes assessed included duration of hospitalisation, rates of re-accumulation and types of bacterial cultures obtained. All patients received antibiotics either as monotherapy (vancomycin, ampicillin/sulbactam, levofloxacin, piperacillin/tazobactam) or as varying combinations of the above. External drainage consisted of either a transcutaneous or transcaruncular drainage approach while combination therapy included endoscopic sinus drainage as an addition.

Tanna[65] performed a retrospective case series of 13 children with subperiosteal orbital abscess who had undergone surgical drainage. All participants were initially managed with parenteral antibiotics and supportive therapy in addition to clinical and radiographic examinations. Outcomes described in the paper included complication rate. It is important to note that, in this paper, of the eight cases that underwent external drainage, six of the cases were initially treated with an endoscopic approach, which had failed and led to recurrence of the abscess and consequently was treated with external drainage. All external drainage techniques initially where done through a Lynch incision. One case of external drainage however had recurrence and was treated externally again via a lateral eyebrow incision due to superolateral abscess extension. Endoscopic drainage was not clearly outlined other than saying it was done trans-nasally.

Suhaili[111] retrospectively reviewed all paediatric cases of orbital complication secondary to acute sinusitis, with patients followed up between two to six months. Of the six cases in the study, one was excluded from our analysis due to it being preseptal cellulitis. Outcomes that were assessed included culture results and rate of cure/recurrence. All patients had mandatory ophthalmological examination, contrast enhanced computed tomography scans of brain/sinus/orbit and intravenous antibiotics (cephalosporin and metronidazole). Most patients also concurrently received nasal decongestants and douching. External drainage was done through an external ethmoidectomy while the exact technique of endoscopic drainage was not clearly outlined.

Hassan[112] performed a retrospective study of 10 patients with orbital complications from acute sinusitis. Although 16 patients were eligible based on inclusion and exclusion criteria, the notes of only 10 patients could be sourced. For our study, we only assessed five of the patients, as the other patients did not display any evidence of subperiosteal or orbital abscess. All cases had contrast enhanced computer tomography scans and clinical examination, and were followed up on average two months post-operatively. Outcomes assessed included culture results and rates of success with surgery. External drainage was done through an external ethmoidectomy while the exact technique of endoscopic drainage was not clearly outlined.

Table 3.01: Summary of included studies

Study	Methods	Participants/Setting	Site/Chandler score	Intervention/Control	Outcomes/Results	Notes

Rubin (2013)[81]	Retrospective case series -	**Participants**
		38 people
		• Age: 1.5-16yo
		• Sex: 19F/19M
		
		Setting
		Hôpital Necker – Enfants Maladess, Paris, France
		
		Inclusion criteria
		• Chandler III SPA secondary to rhinosinusitis
		• Age < 18
			Site
			• Non lateral extension abscess
			
			Chandler
			• III
				External (n=21)
				External drainage via inner canthal incision
				
				Endoscopic (n=12)
				Endoscopic ethmoidectomy with lamina papyracea opening
				
				Combined (n=5)
				Combination of external and endoscopic
					Recurrence
					• EXT: 3/21
					• ENDO: 3/12
					• CA: 0/5
					• **P (EXT vs. ENDO) = 0.37**
					
					Total hospitalisation (day)
					• EXT (mean): 8.2 (range 3-27)
					  ○ SD (EXT vs. ENDO) = 5.54
					  ○ SD (EXT vs. CA) = 6.12
					• ENDO (mean): 5.8 (Range: 3-10)
					  ○ SD (ENDO vs. CA) = 2.68
					• CA (mean): 6.4 (range: 5-9)
					• **P (EXT vs. ENDO) = 0.24**
					
					Post-operative stay (day)
					• EXT (median): 5.4 (range 2-9)
					  • SD (EXT vs. ENDO) = 2.24
					  • SD (EXT vs. CA) = 1.99
					• ENDO (median): 3.1 (range: 2-6)
						Duration of post-operative hospitalisation was significantly shorter in ENDO vs. EXT.
						
						Duration of total hospitalisation did not differ between EXT vs. ENDO.
						
						Nil statistically significance in recurrence rates.

					• CA (median): 4.8 (range: 3-8) ○ SD(EXT vs. CA) = 1.99 • **P (EXT vs. ENDO) = 0.008 (statistically significant)**	
Pelton (2003)[109]	Retrospective Case Series	**Participants** 11 people • Age: 17mo-14yo • Sex: 9F/10M **Setting** Tertiary Paediatric Hospital, University of Utah, USA **Inclusion criteria** Subperiosteal orbital abscess secondary to rhinosinusitis	**Site** • Not specified **Chandler** • III	**External (n=4)** External drainage via transcaruncular approach **Endoscopic (n=1)** Endoscopic ethmoidectomy **Combined (n=6)** Combination of external and endoscopic	**Recurrence** • EXT: 1/4 • ENDO: 1/1 • CA: 0/6 **Total hospitalisation (day)** • EXT (mean): 3 (range: 1-3) • ENDO (mean): 4 (range: 4) • CA (mean): 4.17 (range: 3-7) **Post-operative stay (day)** • EXT (median): 2 (range 1-3) • ENDO (median): 3 (range 3) • CA (median): 2 (range 1-4)	**Revision surgery** • EXT: Revision ENDO 16 months later • ENDO: Revision CA 16 days later
Rahbar(2001) [63]	Retrospective Case Series	**Participants** 19 people • Age: 6wks-13yo	**Site** • 10 medial • 1 infero-	**External (n=3)** External drainage via incision and drainage	**Recurrence** • EXT: 0/3 • ENDO: 2/11	5 cases excluded as they were only treated with IV

		• Sex: 4F/7M **Setting** The Children's Hospital, Boston, Utah **Inclusion criteria** Subperiosteal orbital abscess secondary to rhinosinusitis	medial • 3 superior **Chandler** • III	**Endoscopic (n=11)** Endoscopic ethmoidectomy with lamina papyracea opening	**Total hospitalisation (day)** • EXT (mean): 5.09 (SD 1.3) • ENDO (mean): 9.33 (SD=4) • **P (EXT vs. TEA) = 0.03**	antibiotics solely. Statistical significance in duration of total hospitalisation, with shorter stay in external group. Both endoscopic cases with recurrence underwent a 2nd endoscopic drainage procedure.
Huang(2016)[72]	Retrospective Case Series	**Participants** 18 people • Age: 12 days-18yo • Sex: 4F/7M **Setting** Chang Gung Memorial Hospital, Taiwan **Inclusion criteria** Subperiosteal orbital abscess secondary to rhinosinusitis	**Site** • Not specified **Chandler** • III	**External (n=8)** External drainage via transcaruncular approach **Endoscopic (n=10)** Endoscopic ethmoidectomy with lamina papyracea opening **Combined (n=4)** Combination of Groups 1 and 2	**Total hospitalisation (day)** • EXT (mean ± SD): 16.25 ± 13.6 • ENDO (mean ± SD): 13.0 ± 5.01 • CA (mean ± SD): 21.0 ± 23.57 • **P (EXT vs. ENDO) = 0.578**	Nil statistically significant result between 3 groups in terms of length of total hospitalisation.
Migirov (2009)[67]	Retrospective Case Series	**Participants** 22 people • Age: 8-203	**Site** • 22 medial **Chandler**	**External (n=16)** External drainage via external ethmoidectomy	**Recurrence** • EXT: 1/16 • ENDO: 0/6	Revision EE was done for case that had recurrence

		months
		• Sex: 8F/14M
		
		Setting
		Sheba Medical Centre, Tel Aviv, Israel
		
		Inclusion criteria
		• Medial subperiosteal abscess
		• Age < 18
			• III	**Endoscopic (n=6)**
				Endoscopic ethmoidectomy with partial lamina papyracea opening
					Total hospitalisation (day)
					• EXT (mean ± SD): 9.9 ± 4.2 (range: 5-18)
					• ENDO (mean ± SD): 6.0 ± 2.0 (range: 4-9)
					• **P (EXT vs. ENDO) = 0.02**
					
					Complications
					• EXT:
					  ○ 16/16 scarring
					  ○ 1/16 delayed healing
					  ○ 1/16 stitch abscess
					  ○ 1/16 unresolved diplopia
					  ○ 2/16 recurrent periorbital cellulitis
					    ▪ Child 1: 3 months and 6 months
					    ▪ Child 2: 3 months and 6 years
					• ENDO: 0/6
						Shorter hospital stay associated with endoscopic drainage group.

Dewan (2011)[110]	Retrospective Case Series	**Participants** 15 people • Age: 2yo – 46yo **Setting** ▪ Lions Eye Institute, New York, USA **Inclusion criteria** ▪ Subperiosteal abscess secondary to infectious cases not related to skin, teeth or herpes infection	**Site** • 11 medial • 3 superior • 1 superomedial **Chandler** • III	**External (n=9)** External drainage via transcutaneous/transcaruncular incision **Combined (n=6)** Combination of external drainage and endoscopic sinus drainage	**Recurrence** • EXT: 5/9 • CA: 0/6 • **P (EXT vs. CA) = 0.04**	Statistically significant result, with less recurrence in combined drainage vs. external drainage.
Tanna (2008)[65]	Retrospective Case Series	**Participants** 13 people • Age: 8.7yo (mean) • Sex: 3F/10M **Setting** Children's National Medical Centre, Washington, USA **Inclusion Criteria** • Subperiosteal orbital abscess • Age <18yo	**Site** • 8 Medial 5 Medial + Superolateral **Chandler** • III	**External (n=2)** External drainage via Lynch ± lateral eyebrow incision. **Endoscopic (n=11)** Endoscopic ethmoidectomy	**Recurrence** • EXT: 1/2 • ENDO: 6/11 **Complication** • EXT: 0/2 • ENDO: 0/11	The external case that failed drainage underwent a repeat Lynch Incision. The 6 endoscopic cases were revised with 3 cases having a Lynch incision and 3 cases having a Lynch incision + lateral eyebrow incision.

Suhaili (2010)[111]	Retrospective Case Series	**Participants** 5 people • Age: 3yo – 17yo • Sex: 2F/3M **Setting** Universiti Kebangsaan Malaysia Medical Centre, Kuala Lumpur, Malaysia **Inclusion criteria** Orbital complications secondary to sinusitis	**Site** • Not specified **Chandler** II - 1 case (excluded) III – 4 cases IV – 1 case	**External (n=2)** External drainage via external ethmoidectomy **Endoscopic (n=3)** Endoscopic ethmoidectomy	**Recurrence** • EXT:0/2 • ENDO: 0/3 **Complications** • EXT:0/3 • ENDO: 0/2	1 case excluded due to Chandler II grade and infection secondary to dental source.
Hassan (2013)[112]	Retrospective Case Series	**Participants** • Age: 3yo – 17yo • Sex: 4F/3M **Setting** Universiti Kebangsaan Malaysia Medical Centre, Kuala Lumpur, Malaysia **Inclusion criteria** Orbital complications secondary to sinusitis	**Site** • Not specified **Chandler** • III	**External (n=1)** External drainage via external ethmoidectomy **Endoscopic (n=4)** Endoscopic ethmoidectomy	**Recurrence** • EXT: 2/4 • ENDO: 0/1	Study has 10 participants. 3 participants were excluded from analysis due to 2 cases of Chandler II grading and 1 case of pure medical treatment.

EXT: external; ENDO: endoscopic; CA: combined approach; SD: standard deviation, TEA: transnasal endoscopic approach

3.3 Methodological quality

Table 3.02 displays the individual critical appraisal scores of each study, with scores ranging between 4 and 10. The only paper to meet all inclusion criteria was by Huang.[72] Most of the studies did not meet the criteria due to a lack of definition of exclusion criteria, under-reporting of a site's demographics and varying levels of complete inclusion of participants. Some initial differences were identified between the two reviewers, however a consensus was reached upon discussion. As such, a third reviewer was not required.

Table 3.02: Critical appraisal scores for included descriptive studies

Descriptive	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
Rubin[81]	Y	Y	Y	Y	U	Y	N	Y	Y	Y	8
Pelton[109]	U	U	Y	Y	U	Y	U	Y	U	N/A	4
Rahbar[63]	N	Y	Y	N	U	Y	Y	Y	N	Y	7
Huang[72]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	10
Migirov[67]	N	Y	Y	Y	U	Y	Y	Y	U	Y	7
Dewan[110]	Y	U	Y	Y	Y	Y	Y	Y	U	Y	8
Tanna[65]	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	9
Suhaili[111]	Y	N	Y	Y	N	Y	Y	Y	Y	N/A	7
Hassan[112]	Y	Y	Y	Y	U	Y	Y	Y	Y	N/A	8

Refer to Appendix 2 for critical appraisal questions. Y = yes, N = no, U = unclear, N/A = not applicable

3.4 Results

Results are presented as intervention versus comparator, with the various outcomes being individually explored. Meta-analysis results are presented first, followed by results from studies that could not be pooled. All results are means or proportions. Variance figures are given, where available; a single number in parenthesis represents a standard deviation and where two figures are given, this represents range. Wherever available, p-values and 95% CIs are given.

3.4.1 Comparative analyses

3.4.1.1 Outcomes

3.4.1.1.1 Recurrence

3.4.1.1.1.1 Endoscopic drainage versus external drainage

Analysis of recurrence rates was amenable to meta-analysis with seven descriptive retrospective case series (see Figure 3.??).

	Endoscopic		External			Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI
Hassan 2013	0	1	2	4	8.8%	0.50 [0.04, 6.44]
Migirov 2009	0	6	1	16	6.1%	0.81 [0.04, 17.56]
Pelton 2003	1	1	1	4	23.7%	2.50 [0.53, 11.89]
Rahbar 2001	2	11	0	3	7.3%	1.67 [0.10, 27.90]
Rubin 2013	3	12	3	21	28.0%	1.75 [0.42, 7.35]
Suhaili 2010	0	3	0	2		Not estimable
Tanna 2008	6	11	1	2	26.1%	1.09 [0.25, 4.83]
Total (95% CI)		**45**		**52**	**100.0%**	**1.43 [0.67, 3.06]**
Total events	12		8			

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 1.51$, $df = 5$ ($P = 0.91$); $I^2 = 0\%$
Test for overall effect: $Z = 0.93$ ($P = 0.35$)

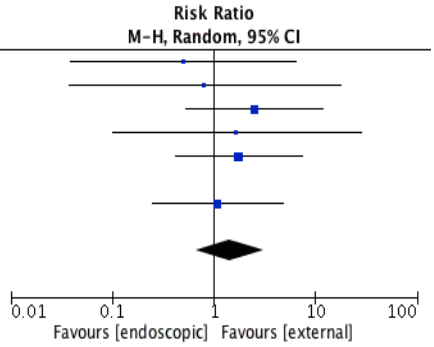

Figure 3.02: Meta-analysis of recurrence rates in descriptive studies comparing endoscopic drainage to external drainage

The results from the studies assessing recurrence were homogenous in nature (I^2=0.00%, Chi^2 p=0.91). It can be seen that there is a trend towards a higher risk of recurrence in the endoscopic group (RR 1.43) with the three higher weighted studies showing a high risk ratio. This result is however not statistically significant (95% CI 0.67-3.06 p = 0.35).

Narrative description of recurrence results

Rubin[81] reported recurrence rates of 3/21 (14.3%) in the external group and 3/12 (25%) in the endoscopic group, with no statistical difference identified (p = 0.37). All of their three endoscopic cases were repeated with external drainage with two of these requiring a consequent combined drainage procedure. Interestingly, it should be noted here that the risk of surgical failure in endoscopic drainage was positively correlated with abscess width, length width/orbital diameter ratio and length/orbital diameter ratio. All three cases of endoscopic failure also involved inferior or lateral extension of the abscess. Tanna's[65] reporting of data was difficult to analyse in that, of their eight patients whom they classed as 'external drainage', six of the cases were actual failed endoscopic drainage attempts, resulting in abscess recurrence that needed treating. Thus 6/11 (55%) of endoscopic cases encountered recurrence and 1/2 (50%) of external cases had recurrence. All cases were managed externally with either a Lynch or lateral eyebrow incision. Tanna also reported that external drainage techniques were more likely to have a higher rate of extraocular muscle involvement (medial rectus, superior rectus and super oblique muscles) and that all five superolateral cases were eventually treated with an external drainage approach (three initially with an endoscopic approach). Migirov[67] reported a recurrence rate of 1/16 (6.25%) in external drainage and 0/6 (0%) in the endoscopic group. The case of recurrence was treated with another external ethmoidectomy. It is also noted that two children in the external drainage group developed recurrent periorbital cellulitis (Chandler I) that was successfully managed conservatively. Rahbar[63] described recurrence rates of 0/3 (0%) in external drainage and 2/11 (18%) in endoscopic drainage, with both recurrence cases undergoing repeat endoscopic drainage. The reasons for re-operation for both the cases were ongoing purulent collection within posterior ethmoid/orbital subperiosteum and formation of an organised clot/collection of antibiotic ointment that was obstructing the ethmoid cavity and lamina opening. All cases of external drainage consisted of superiorly located abscesses while all endoscopic cases were medially located. Pelton[109] reported recurrence rates of 1/4 (25%) in external drainage and 1/1 (100%) in endoscopic drainage. The case of recurrence in the endoscopic group was treated with a transcaruncular drainage approach with sinus endoscopy (without intervention). Interestingly, however, the case of recurrence in the external group was managed with an endoscopic ethmoidectomy, which was the first case in all the studies to follow this pattern.

3.4.1.1.1.2 Combined drainage versus external drainage

Analysis of recurrence rates was amenable to meta-analysis with three descriptive retrospective case series (see Figure 3.03).

	Combined		External			Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI
Dewan 2011	0	6	5	9	36.1%	0.13 [0.01, 1.99]
Pelton 2003	0	6	1	4	30.1%	0.24 [0.01, 4.72]
Rubin 2013	0	5	3	21	33.8%	0.52 [0.03, 8.81]
Total (95% CI)		**17**		**34**	**100.0%**	**0.25 [0.05, 1.29]**
Total events	0		9			

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.50$, df = 2 (P = 0.78); $I^2 = 0\%$
Test for overall effect: Z = 1.66 (P = 0.10)

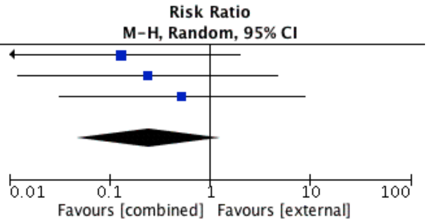

Figure 3.03: Meta-analysis of recurrence rates in descriptive studies comparing combined drainage to external drainage

The studies assessing recurrence were homogenous in nature (I^2=0.00%, Chi^2 p=0.0.78). There were no cases of recurrence identified in the combined drainage group in all 17 cases. It can be seen that there was a trend towards a higher risk of recurrence in the external group (RR 0.25). This result is statistically significant (95% CI 0.05-1.29 p = 0.10).

3.4.1.1.1.3 Endoscopic drainage versus combined drainage

Analysis of recurrence rates was amenable to meta-analysis with two descriptive retrospective case series (see Figure ??).

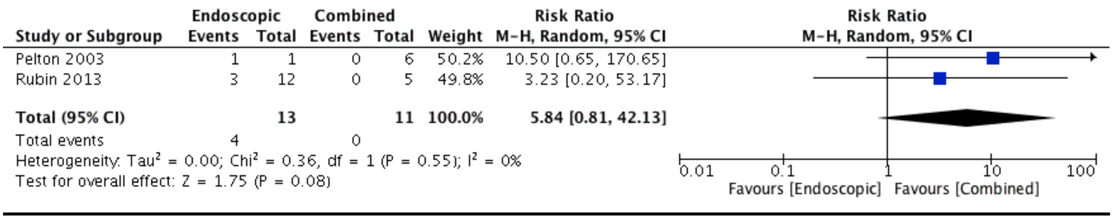

Figure 3.04: Meta-analysis of recurrence rates in descriptive studies comparing endoscopic drainage to combined drainage

The studies assessing recurrence were homogenous in nature (I^2=0.00%, Chi^2 p=0.0.55). There were no cases of recurrence identified in the combined drainage group, out of all 11 cases. It can be seen that there was a trend towards a higher risk of recurrence in the endoscopic group (RR 5.84). This result is however not statistically significant (95% CI 0.81-42.13 p = 0.08).

3.4.1.1.2 Total hospitalisation (days)

3.4.1.1.2.1 Endoscopic drainage versus external drainage

Study or Subgroup	Endoscopic Mean	Endoscopic SD	Endoscopic Total	External Mean	External SD	External Total	Weight	Mean Difference IV, Random, 95% CI
Huang 2016	21	5.01	10	16.25	13.6	8	13.8%	4.75 [-5.17, 14.67]
Migirov 2009	6	2	6	9.9	4.2	16	29.8%	-3.90 [-6.51, -1.29]
Pelton 2003	4	0	1	3	1.41	4		Not estimable
Rahbar 2001	9.33	4	11	5.09	1.3	3	29.5%	4.24 [1.46, 7.02]
Rubin 2013	5.8	5.54	12	8.2	5.54	21	26.9%	-2.40 [-6.33, 1.53]
Total (95% CI)			**39**			**48**	**100.0%**	**0.10 [-4.76, 4.96]**

Heterogeneity: $Tau^2 = 18.83$; $Chi^2 = 19.62$, df = 3 (P = 0.0002); $I^2 = 85\%$
Test for overall effect: Z = 0.04 (P = 0.97)

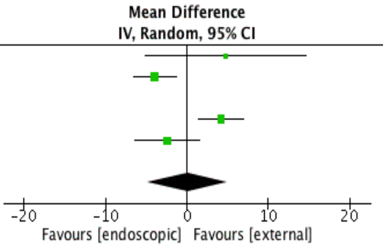

Figure 3.05: Meta-analysis of total hospitalisation rates in studies comparing endoscopic drainage to combined drainage

The studies assessing total hospitalisation were largely heterogeneous in nature (I^2=18.83%, Chi^2 p=0.0002). It can be seen that there was a very slight trend towards a higher average total hospitalisation stay in the endoscopic group (mean difference 0.10) – see Figure 3.05. This result is statistically significant (95% CI -4.76-4.96 p = 0.97). Given this large confidence interval, it is difficult to extrapolate and confirm a conclusive hypothesis.

As some of the studies did not report a standard deviation, hence the standard deviation was calculated/estimated from the data that was provided. The study by Pelton[109] provided data per participant in a table format. The mean total hospitalisation and standard deviation were self-calculated for the external group, however as there was only one participant in the endoscopic group, it could not be included in the meta-analysis as there was no standard deviation. In Rahbar's[63] study, data per participant was provided in a table format. We calculated our own mean total hospitalisation and standard deviation for both groups. In Rubin's[81] study, an approximate standard deviation was calculated using the p-value for difference in means. This was conducted based on guidance from the Cochrane Handbook.[113]

3.4.1.1.2.2 Combined drainage versus external drainage

	Combined			External				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Huang 2016	21	23.57	4	16.25	13.6	8	0.5%	4.75 [-20.20, 29.70]
Pelton 2003	4.17	1.47	6	3	1.41	4	91.1%	1.17 [-0.64, 2.98]
Rubin 2013	6.4	6.12	5	8.2	6.12	21	8.4%	-1.80 [-7.77, 4.17]
Total (95% CI)			**15**			**33**	**100.0%**	**0.94 [-0.79, 2.67]**

Heterogeneity: Tau² = 0.00; Chi² = 0.96, df = 2 (P = 0.62); I² = 0%
Test for overall effect: Z = 1.06 (P = 0.29)

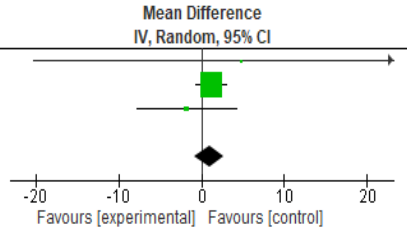

Figure 3.06: Meta-analysis of total hospitalisation in descriptive studies comparing combined drainage to external drainage

The studies assessing total hospitalisation were homogenous in nature (I^2=0%, Chi^2 p=0.62). It can be seen that there was a slight trend towards a higher average total hospitalisation stay in the combined group (mean difference 0.94). This result is statistically significant (95% CI -0.79-2.67 p = 0.29) – See Figure 3.06.

Some of the studies did not report a standard deviation, hence the standard deviation was calculated/estimated from the data that was provided. The study by Pelton[109] provided data per participant in a table format. The mean total hospitalisation and standard deviation were self-calculated for the external group. In Rubin's[81] study, an approximate standard deviation was calculated using the p-value for difference in means. This was conducted based on guidance from the Cochrane Handbook.[113]

3.4.1.1.2.3 Endoscopic drainage versus combined drainage

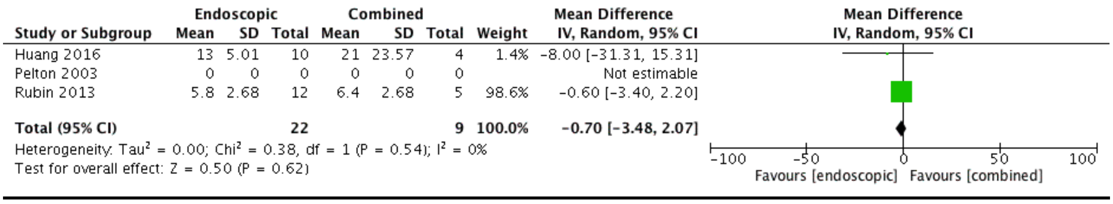

Figure 3.07: Meta-analysis of total hospitalisation in descriptive studies comparing endoscopic drainage to combined drainage

The studies assessing total hospitalisation were homogenous in nature (I^2=0%, Chi^2 p=0.0.54). It can be seen that there was a slight trend towards a higher average total hospitalisation stay in the combined group (Mean Difference -0.70). This result is not statistically significant (95% CI -3.48-2.07 p = 0.62) – see Figure 3.07.

Some of the studies did not report a standard deviation, hence the standard deviation was calculated/estimated from the data that was provided. The study by Pelton[109] provided data per participant in a table format. The mean total hospitalisation and standard deviation were self-calculated for the combined group, however as there was only one participant in the endoscopic group, it could not be included in the meta-analysis as there was no standard deviation.

3.4.1.1.3 Post-operative stay (days)

3.4.1.1.3.1 Endoscopic drainage versus external drainage

Given that there were only two studies (Rubin and Pelton) comparing these outcomes, a meta-analysis could not be performed. The study by Rubin[81] was a statistically significant comparative study (p[EXT] vs. p[ENDO] = 0.008), with a post-operative stay of 5.4 ± 2.24 (mean ± SD) (range: 2-9) in the external group and 3.1 ± 2.24 (mean ± SD): (range: 2-6) in the endoscopic group. The Pelton study showed a post-operative stay of 2.0 ± 0.82 (mean ± SD) (range: 1-3) in the external group and a mean of 3.0 in the endoscopic group.

3.4.1.1.3.2 Combined drainage versus external drainage

	Combined			External				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Pelton 2003	2	1.03	6	2	0.82	4	74.0%	0.00 [-1.15, 1.15]
Rubin 2013	4.8	1.99	5	5.4	1.99	21	26.0%	-0.60 [-2.54, 1.34]
Total (95% CI)			**11**			**25**	**100.0%**	**-0.16 [-1.15, 0.83]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.27$, df = 1 (P = 0.60); $I^2 = 0\%$
Test for overall effect: Z = 0.31 (P = 0.76)

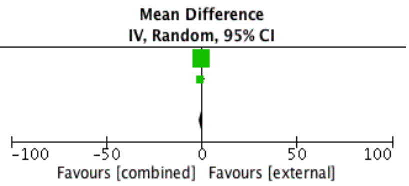

Figure 3.08: Meta-analysis of post-operative stay in descriptive studies comparing combined drainage to external drainage

The studies assessing post-operative stay were homogenous in nature (I^2=0%, Chi^2 p=0.6). It can be seen that there is a very slight trend towards a higher average post-operative stay in the external group (Mean Difference -0.16). This result is not statistically significant (95% CI -1.15-0.83 p = 0.76) – see Figure 3.08. Some of the studies did not report a standard deviation and so the standard deviation was calculated/estimated from the data that was provided. In Rubin's[81] study, an approximate standard deviation was calculated using the p-value for difference in means. This was conducted following guidance from the Cochrane Handbook.[113]

3.4.1.1.3.3 Endoscopic drainage versus combined drainage

Given that there are only two studies (Rubin and Pelton) comparing these outcomes, a meta-analysis could not be performed. In Rubin's study, the median post-operative stay was slightly higher in combined drainage (4.8 ± 1.99 [range: 3-8]) compared to endoscopic drainage (3.1 ± 1.99 [range: 2-6]). The study by Pelton[109] provided data per participant in a table format. The mean post-operative stay and standard deviation were self-calculated for the combined group, however there was only one participant in the endoscopic group. It showed a post-operative stay of 3.0 (mean) in the endoscopic group and 2 ± 1.03 (mean ± SD) (range: 1-4) in the combined group.

3.4.2 Single group analyses

The single group analyses below outline the results of the studies looking at external, endoscopic and combined surgical drainage techniques. For continuous outcomes, studies with less than two patients in the sample size were excluded, as the standard deviation could not be calculated. Single group results were extracted from all studies, where possible. Means were taken and standard deviation used as a measure of variance. Where no variance measure was included, the study was only included in the analysis if sufficient data was provided to calculate an approximate standard deviation. Where range or p-value was given instead of standard deviation, guidance from the Cochrane Handbook[113] was used to calculate a standard deviation. This is not necessarily a perfect approach and does have some inherent inaccuracy. It did however allow for inclusion of a greater possible number of studies, which added to the strength of our single group analysis. OpenMeta [Analyst][103] and StatsDirect[105] software were used for statistical analyses. Single group analyses were performed for recurrence rates, total hospitalisation stay (days) and post-operative stay (days).

Complication rates will be reported narratively. Results are presented in a forest plot format.

3.4.2.1 External drainage

3.4.2.1.1 Recurrence

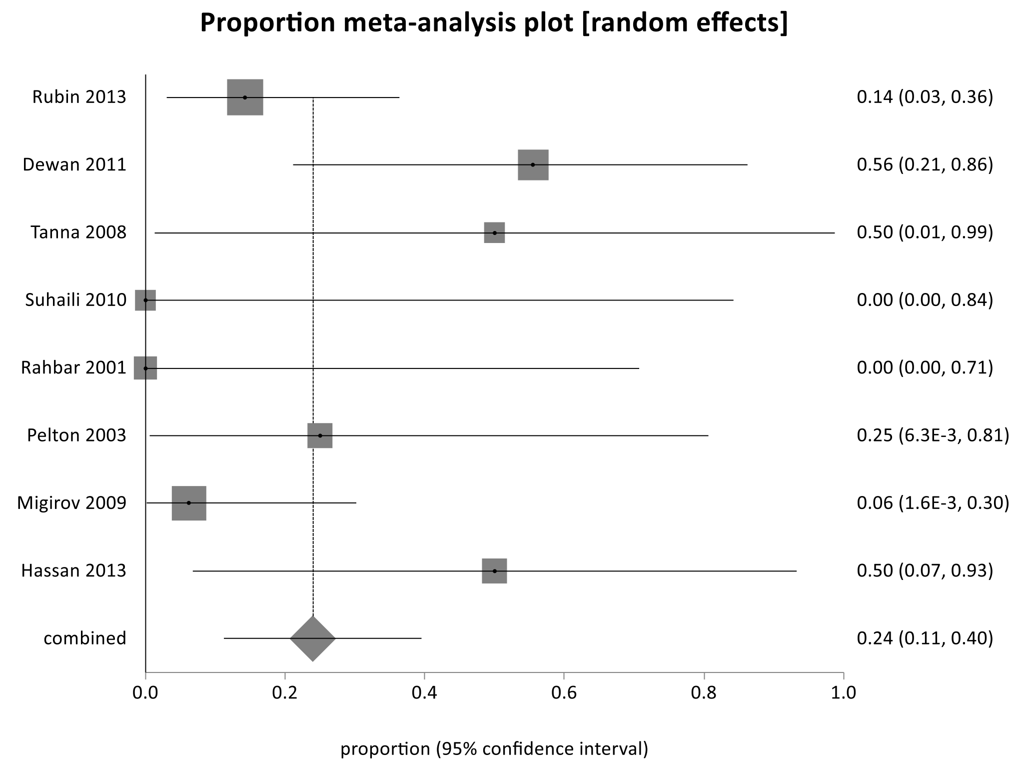

Figure 3.09: Single group analysis of recurrence rate in descriptive studies assessing external drainage

Table 3.03: Weighting of individual descriptive studies assessing recurrence in external drainage

Study	Standardised effect	Variance	Weighting (random) (%)
Rubin 2013	0.142857	0.046512	23.221759
Dewan 2011	0.555556	0.105263	15.905313
Tanna 2008	0.5	0.4	6.163432
Suhaili 2010 [97.5% one-sided CI]	0	0.4	6.163432
Rahbar 2001 [97.5% one-sided CI]	0	0.285714	8.083157
Pelton 2003	0.25	0.222222	9.774533
Migirov 2009	0.0625	0.060606	20.913842
Hassan 2013	0.5	0.222222	9.774533

A proportional meta-analysis was performed for recurrence rates in studies assessing external drainage (see Figure 3.09). Overall the recurrence rate was 24% (95% CI 11-40) with a moderate level of heterogeneity between the studies (I^2 = 37.3%, Chi p = 0.1315). Table 3.03 describes the weighting of the studies involved, with Rubin[81], Migirov[67] and Dewan[110] accounting for the majority of the weighting.

3.4.2.1.2 Total hospitalisation (days)

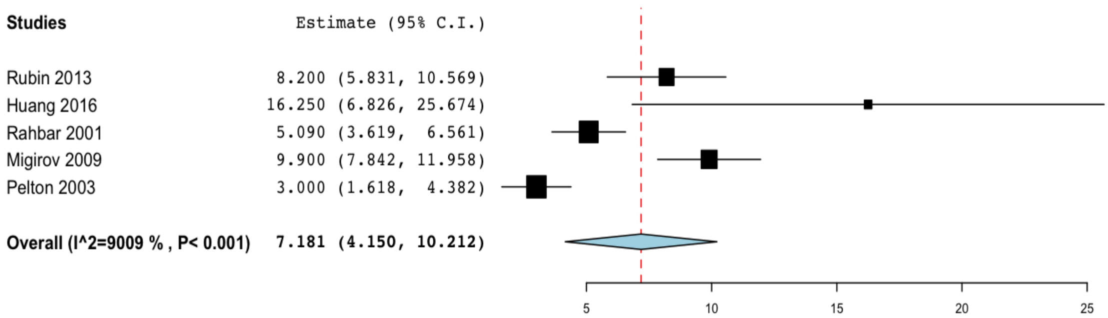

Figure 3.10: Single group analysis of total hospitalisation in descriptive studies assessing external drainage

Table 3.04: Weighting of individual descriptive studies assessing total hospitalisation in external drainage

Study	Weighting (%)
Rubin 2013	21.950
Huang 2016	7.346
Rahbar 2001	23.923
Migirov 2009	22.698
Pelton 2003	24.083

A single group analysis was performed for total hospitalisation in studies assessing external drainage (see Figure 3.10). Overall the mean total hospitalisation (days) was 7.181 days (95% CI 4.150-10.212), with a large level of heterogeneity between the studies (I^2 = 90.09%, p = 0.001). Table 3.04 outlines the weighting of studies, with a reasonable even spread of weighting, excluding the study by Huang.[72]

3.4.2.1.3 Post-operative stay (days)

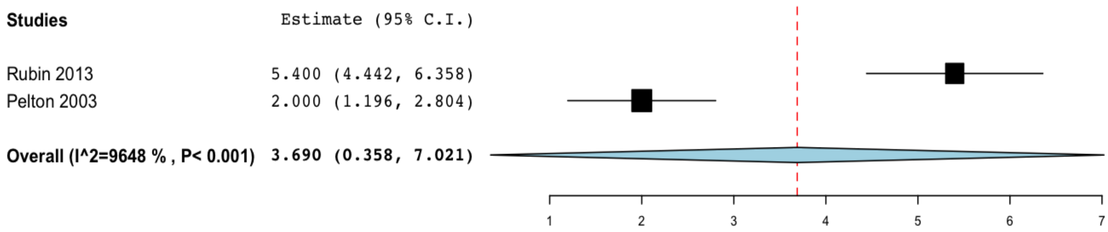

Figure 3.11: Single group analysis of post-operative stay in descriptive studies assessing external drainage

Table 3.05: Weighting of Individual descriptive studies assessing post-operative stay in external drainage

Study	**Weighting (%)**
Rubin 2013	49.694
Pelton 2003	50.306

A single group analysis was performed for post-operative stay in studies assessing external drainage (see Figure 3.11). Overall the mean post-operative stay (days) was 3.690 days (95% CI 0.358-7.021), with a high level of heterogeneity between studies (I^2 = 96.48%, p = 0.001). Table 3.05 outlines the weighting of the studies in the single group analysis, with Pelton[109] having a slightly higher weighting, by 0.612%.

3.4.2.1.4 Complication rate

The three cases of external drainage performed by Tanna[65] and Suhaili[111] did not register any complications. Migirov[67] reported that all 16 children who underwent external drainage had post-operative facial scarring. Additionally, there was an individual complication of delayed healing, stitch abscess and unresolved diplopia reported. There were also two children who had recurrent episodes of periorbital cellulitis within a six-year period.

3.4.2.2 Endoscopic drainage

3.4.2.2.1 Recurrence rate

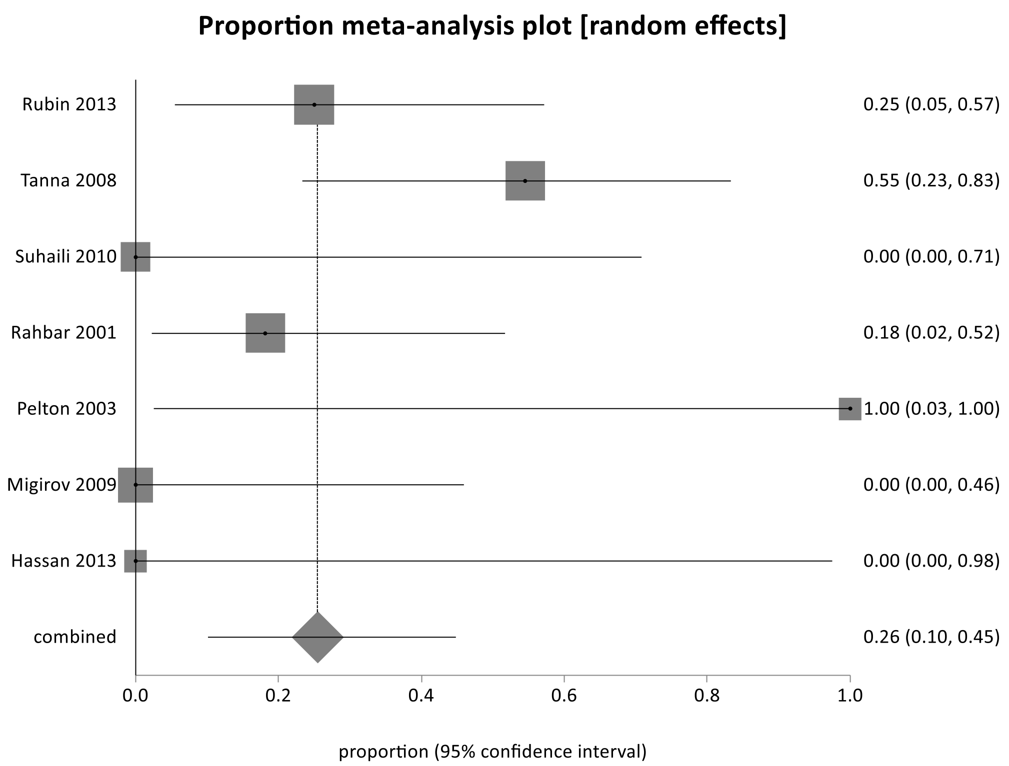

Figure 3.12: Single group analysis of recurrence rate in descriptive studies assessing endoscopic drainage

Table 3.06: Weighting of individual descriptive studies assessing recurrence in endoscopic drainage

Study	Standardised effect	Variance	Weighting (random) (%)
Rubin 2013	0.25	0.08	21.360585
Tanna 2008	0.545455	0.086957	20.65568
Suhaili 2010 [97.5% one-sided CI]	0	0.285714	10.63156
Rahbar 2001	0.181818	0.086957	20.65568
Pelton 2003 [97.5% one-sided CI]	1	0.666667	5.50815
Migirov 2009 [97.5% one-sided CI]	0	0.153846	15.680195
Hassan 2013 [97.5% one-sided CI]	0	0.666667	5.50815

CI: confidence interval

A single group analysis was performed for recurrence rates in studies assessing endoscopic drainage (see Figure 3.12). Overall, the recurrence rate was 26% (95% CI 10-45), with a moderate level of heterogeneity between studies (I^2 = 44.3%, p = 0.0954). Table 3.06 describes the weighting of the studies in the analysis, with Pelton[109] and Hassan[112] having the lowest weighting while the others were more evenly spread.

3.4.2.2.2 Total hospitalisation (days)

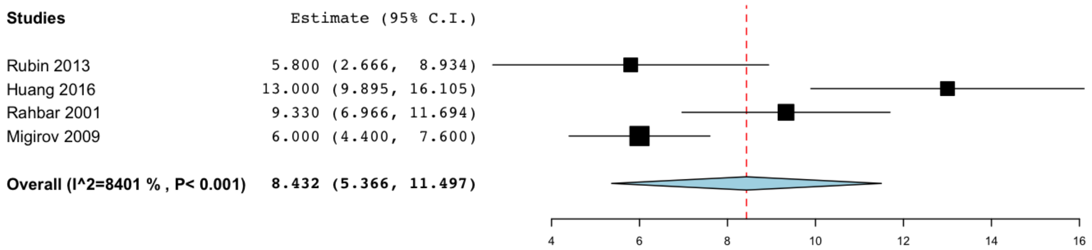

Figure 3.13: Single group analysis of total hospitalisation in descriptive studies assessing endoscopic drainage

Table 3.07: Weighting of individual descriptive studies assessing total hospitalisation in endoscopic drainage

Study	**Weighting (%)**
Rubin 2013	23.055
Huang 2016	23.159
Rahbar 2001	25.730
Migirov 2009	28.055

A single group analysis was performed for post-operative stay in studies assessing endoscopic drainage (see Figure 3.13). Overall the mean post-operative stay (days) was 8.432 days (95% CI 5.366-11.497), with a large level of heterogeneity between studies (I^2 = 84.01%, p = 0.001). Table 3.07 outlines the weighting of the studies in the analyses, with reasonably equal distribution throughout.

3.4.2.2.3 Post-operative stay (days)

There were only two studies that assessed post-operative stay within an endoscopic group. The study by Pelton[109] provided data per participant in a table format. The mean post-operative stay and standard deviation could not be calculated, given that there was only one subject in the endoscopic group. The study by Rubin[81] was a statistically significant comparative study (p[EXT] vs. p[ENDO] = 0.008), with a post-operative stay of 3.1 ± 2.24 days (mean ± SD): (range: 2-6) in the endoscopic group.

3.4.2.2.4 Complication rate

Of the 19 cases performed endoscopically by Tanna[65], Suhaili[111] and Migirov[67], none recorded any complications.

3.4.2.3 Combined drainage

3.4.2.3.1 Recurrence

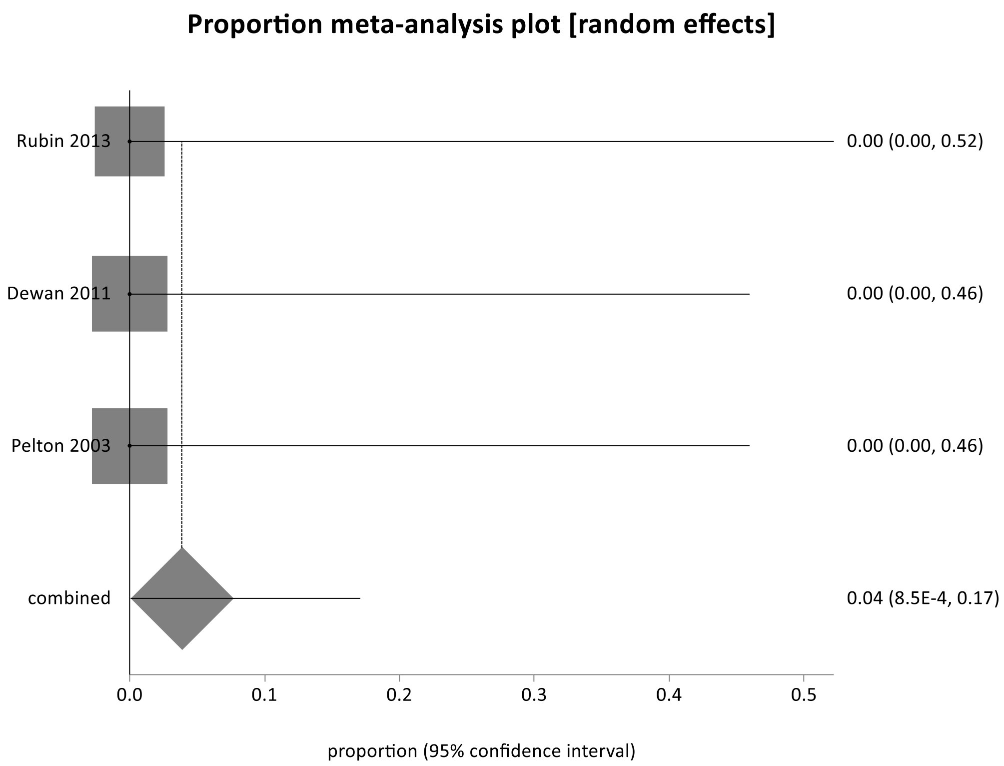

Figure 3.14: Single group analysis of recurrence rates in descriptive studies assessing combined drainage

Table 3.08: Weighting of individual descriptive studies assessing recurrence in combined drainage

Study	**Standardised effect**	**Variance**	**Weighting (random) (%)**
Rubin 2013 [97.5% one-sided CI]	0	0.181818	29.72973
Dewan 2011 [97.5% one-sided CI]	0	0.153846	35.135135
Pelton 2003 [97.5% one-sided CI]	0	0.153846	35.135135

CI: confidence interval

A single group analysis was performed for recurrence rates in studies assessing combined drainage (see Figure 3.14). There were no documented cases of recurrence in the combined drainage group. Overall the recurrence rate was 4% (95% CI 0.08-17.12), with a good level of homogeneity between studies ($I^2 = 0\%$, p = 0.9979). Table 3.08 outlines the weighting of the studies involved in the analysis, with an equal distribution of all studies. However, given there were no events that occurred in any study, this result should be interpreted with this knowledge.

3.4.2.3.2 Total hospitalisation (days)

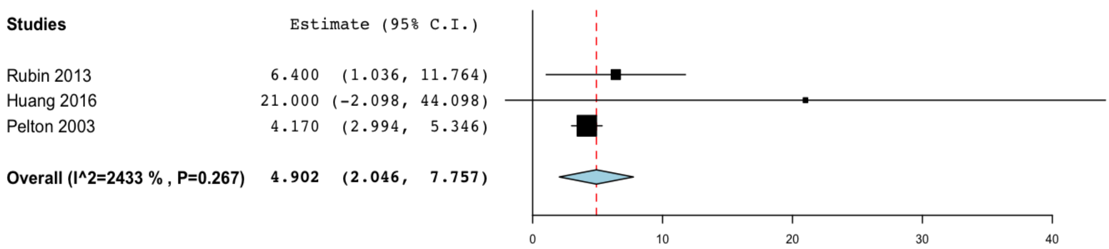

Figure 3.15: Single group analysis of total hospitalisation in descriptive studies assessing combined drainage

Table 3.09: Weighting of individual descriptive studies assessing total hospitalisation in combined drainage

Study	Weighting (%)
Rubin 2013	21.470
Huang 2016	1.502
Pelton 2003	77.027

A single group analysis was performed for total hospitalisation in studies assessing combined drainage (see Figure 3.15). Overall, the mean total hospitalisation (days) was 4.902 days (95% CI 2.046-7.757), with some heterogeneity between studies (I^2 = 24.33%, p = 0.267). Table 3.09 outlines the weighting of the studies involved, with Pelton[109] accounting for the majority of the weighting.

3.4.2.3.3 Post-operative stay (days)

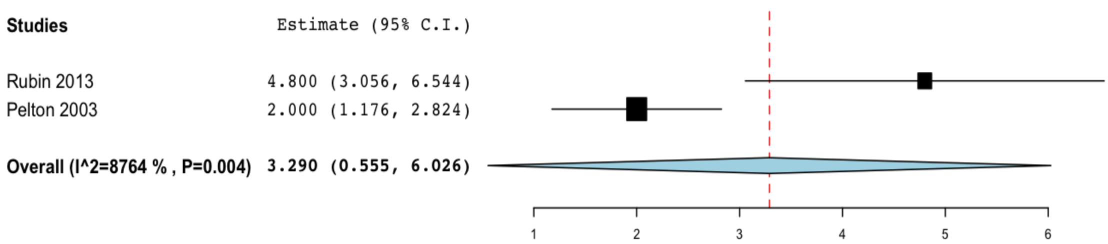

Figure 3.16: Single group analysis of post-operative stay in descriptive studies assessing combined drainage

Table 3.10: Weighting of individual descriptive studies assessing post-operative stay in combined drainage

Study	**Weighting (%)**
Rubin 2013	46.077
Pelton 2003	53.923

A single group analysis was performed for post-operative stay in studies assessing combined drainage (see Figure 3.16). Overall, the mean post-operative stay (days) was 3.290 days (95% CI 0.555-6.026), with a high level of heterogeneity between studies (I^2 = 87.642%, p = 0.004). Table 3.10 outlines the weighting of the studies in the analysis, with Pelton[109] having a greater weighting, by 7.846%.

4 Discussion

This chapter elaborates on and discusses the results of the systematic review that have been reported in the last chapter. Each of the outcomes is explored, with specific comparisons made between the different surgical drainage techniques. The review limitations and implications for clinical practice are explored in the latter portion of this chapter.

4.1 Abscess location and choice of surgical technique

The majority of the nine included studies chose to focus on purely medially located abscesses and compare the use of external, endoscopic or combined drainage. Studies by Pelton[109], Huang[72], Suhaili[111] and Hassan[112] did not specify the location of the abscess within the orbital space. In Rahbar's[63] study, of the 11 endoscopically drained cases, 10 were medially located while one was infero-medially based. The three externally drained cases were isolated to superiorly based abscesses. In Dewan's[110] study, of the four superior/supramedially located abscesses, three underwent a purely external drainage and one was drained via a combined approach. In Tanna's[65] study, all five patients with superolateral extension were successfully treated via external drainage, with three of these patients being initially treated with an endoscopic approach that failed and that required external drainage. The other two were treated initially with an external approach, with one of the cases requiring a repeat external drainage (via lateral eyebrow Incision) after initially undergoing a Lynch incision procedure. Noordzij[91] reported a case of lateral recurrence after endoscopic drainage of an inferiorly located abscess and stated that the risk of incomplete drainage appeared higher in this subgroup. It is clear from this that there was a trend towards either an external or combined approach being the preferred option for inferiorly, superiorly or laterally located abscesses. Although endoscopic techniques, such as those in the Roithmann[80] study, were used for the management of superiorly located abscesses, a pattern of this not being the preferred technique, perhaps due to inadequate access to the lateral or superior compartments via an endoscopic approach, is observed.

4.2 Recurrence

All of the studies in comparative meta-analyses for recurrence were homogenous in nature. Comparative meta-analyses between endoscopic and external drainage groups demonstrated that although there was a higher risk of recurrence in the endoscopic group (RR 1.43), it was not statistically significant (95% CI 0.67-3.06 p = 0.35). There were no cases of recurrence in any of the studies assessing combined drainage, and comparative meta-analysis with external drainage revealed that there was a statistically significant higher risk of recurrence with external drainage (RR 0.25, 95% CI 0.05-1.29 p = 0.10). The small risk ratio shown here suggests that there may be marginal benefit in reducing recurrence by additionally draining an abscess endoscopically after initial external drainage. Interestingly, the comparative meta-analysis between combined and endoscopic drainage groups showed that there was a significantly higher risk of recurrence in endoscopic drainage (RR 5.84) but without it being a statistically significant result (95% CI 0.81-42.13 p = 0.08). This is despite there being no cases of recurrence in the combined group. Given that there were only two studies in this comparison and that such a wide confidence interval was noted in the analysis, a larger sample size is needed to give more power to the analysis whereby one would assume that the risk of recurrence is higher in endoscopic drainage. Single group analysis showed that the overall rate of recurrence was much lower in the combined group (4%, 95% CI 0.08-17.12) in comparison to the external (24%, 95% CI 11-40) or endoscopic groups (26%, 95% CI 10-45). Although the sample size in the combined group was much lower than that in the external or endoscopic groups, the marked difference in recurrence rates suggest that it may be a superior option in preventing abscess recollection. This would however have to be weighed against the various potential complications associated with conducting an external drainage procedure, particularly in a younger patient where scarring and potential webbing are disadvantageous on a long-term scale.

It has been hypothesised that recurrence rates may be lower in externally drained cases as it allows for post-operative irrigation through the incision site and provides a more direct and efficient drainage port for larger abscesses, particularly those with lateral extension. In the Rubin[81] study, there was a positive correlation between size/extension of the abscess and the rate of recurrence with endoscopic drainage. All of their three cases of endoscopic drainage failure also involved abscesses that extended inferiorly or laterally. A similar phenomenon was encountered in the Tanna[65] study, with all five superolateral cases being treated with an external drainage approach (three of which were initially attempted with an endoscopic approach which resulted in recurrence). As such, an external or combined approach might have been more appropriate in cases of lateral, inferior or superior extension.

Not all of the studies reported on whether the lamina papyracea was opened during drainage. Interestingly, Huang[72] attributed the most common reason of recurrence to either inadequate removal of the lamina papyracea or superior/lateral abscess extension that was difficult to drain endoscopically. Rubin[81] reported that opening of the lamina during an endoscopic approach did not influence recurrence rates. Similarly, Khalifa[114] described this phenomenon in external drainage, whereby lamina papyracea extension did not influence recurrence rates either. A retrospective study by Sciarretta[71] involving 10 purely endoscopically drained cases of subperiosteal abscesses found that complete opening of the lamina papyracea was necessary after abscess recurrence was found following the opening of only the anterior portion. As such, this remains a contentious issue and a point of reference for analysis in further research.

4.3 Total hospitalisation (days)

There was a mixed level of homogeneity and heterogeneity in the studies for comparative analyses between external, endoscopic and combined drainage. Studies comparing endoscopic and external drainage techniques were largely homogenous (I^2=18.83%, Chi^2 p=0.0002), while the other comparisons demonstrated good levels of homogeneity. All comparative analyses produced statistically significant results. Endoscopic drainage was associated with a slightly longer total hospitalisation than external drainage (mean difference 0.10, 95% CI -4.76 to 4.96 p=0.97). The large confidence interval shown is a reflection of the heterogeneity of the data and suggests that a greater sample size is needed to further narrow down the proper difference in stay between the groups. Combined drainage was associated with slightly longer total hospitalisation than external drainage (mean difference 0.94, 95% CI -0.79 to 2.67 p = 0.29). Combined drainage was associated with longer total hospitalisation than endoscopic drainage (mean difference -0.70, 95% CI -3.48 to 2.07 p = 0.62). Clinically, the difference in total hospitalisation between all the groups was negligible (i.e. less than one day), thereby suggesting that one technique was not marginally beneficial in reducing hospital stay and hence would most likely not have had an effect on reducing improving costs for the health system. In single group analysis, total hospitalisation stay showed a degree of variation between the combined drainage group and the external and endoscopic drainage group. Mean total hospitalisation was 7.181 days in the external group, 8.432 days in the endoscopic group and 4.902 days in the combined drainage group, with a large degree of heterogeneity between all studies. This is a surprising result given that longer total hospitalisation and post-operative stay have been noted in externally drained abscesses in previous studies.[8, 9, 63]

It is difficult to comment on whether a particular approach resulted in shorter hospitalisation than the other, as in many studies it was not clearly reported as to which day the surgical drainage procedure commenced after the patient was admitted to hospital. For example, in the study by Rubin[81], there was no significant difference in length of total hospitalisation despite endoscopic approaches having more frequent recurrence rates, thereby requiring revision surgery. This may be attributed to the fact that the delay between ethmoiditis commencement/admission and actual surgery was much lower in the endoscopic group. A retrospective case series review by Cheng[83] that assessed adverse events in endoscopic surgery for orbital complications of sinusitis similarly explored this issue. They found that that their endoscopic cases were associated with prolonged hospitalisation secondary to a delay in commencement of surgery. This however proved to be advantageous as it allowed them to trial non-invasive therapy with intravenous antibiotics and monitor for any effect as well as observe a majority of adverse events during this period. As such, further research is warranted to assess whether minimising the delay in operative intervention and standardising the commencement of surgery between both the comparative and control groups can help improve length of hospitalisation.

4.4 Post-operative stay (days)

Comparative meta-analyses could only be performed to compare external and combined groups. There was a statistically significant longer post-operative stay in the external drainage group when compared to the combined drainage group (mean difference -0.16, 95% CI -1.15-0.83 p = 0.76). Clinically, this is of little significance, with a potential difference of 3.84 hours of post-operative stay being saved through a combined drainage procedure. In single group analyses, there was little difference recorded in mean post-operative stay between the external group (3.690 days [95% CI 0.358-7.021]) and combined drainage group (3.290 days [95% CI 0.555-6.026]). Single group analysis could not be performed on the endoscopic group. This was due to the study by Pelton[109] having only one subject in the endoscopic group, thereby making standard deviation and mean post-operative stay incalculable.

The study by Rubin[81] was a statistically significant comparative study (p[EXT] vs. p[ENDO] = 0.008), with a post-operative stay of 3.1 ± 2.24 days (mean ± SD): (range: 2-6) in the endoscopic group. Previous studies by Page[8], Arjmand[9] and Rahbar[63] have observed a longer post-operative stay in externally drained abscesses compared to endoscopically drained abscesses. Possible hypotheses for this include a greater amount of surgical trauma to the palpebral tissues and subperiosteum, resulting in a greater amount and slower regression of post-operative oedema. Additionally, it may be due to the fact that external drainage is often used for more severe abscesses that extend into lateral and superior compartments.

Another issue to consider that has been similarly addressed in the previous chapter is that of standardisation in commencement of surgery between the different surgical groups. Once again, it is difficult to clearly comment on differences in post-operative stay and implementing change in a clinical framework when different surgeries commenced at different times. If all abscesses were operated on much earlier (e.g. within 48 hours of admission) or much later (e.g. 72-96 hours after admission, with an initial trial of intravenous antibiotics), then it would be fair to compare both techniques in relation to length of post-operative stay based on the severity of the disease. Admittedly, there are confounders, such as when the patients choose to present to hospital after ethmoiditis/sinusitis has commenced, which are near impossible to control and would need to be accounted for within the analysis.

4.5 Complication rate

Of the three papers that assessed complication rates, none of the studies reported any complications within the 19 endoscopic drainage cases. The only paper to register any complication was that by Migirov, which demonstrated facial scarring (16/16 patients), delayed healing (1/16 patients), stitch abscess (1/16 patients) and unresolved diplopia (1/16 patients) in patients who underwent external drainage. It is clear that more studies with a larger sample size is needed to elicit the true complication rates with these surgical procedures. Additionally, there was no standardised follow-up time which meant that possible complications would have been missed, leading to a consequential under-reporting of these outcomes. Migirov[67] also reported that post-operative oedema was markedly less in those who underwent endoscopic drainage versus external drainage, a finding that is similarly shared by the Page[8] retrospective study comparing endoscopic and external surgical drainage techniques. One of the under-reported complications of endoscopic drainage in this systematic review is that of bleeding of acutely inflamed mucosal tissue.[6, 7, 91] This is important because excessive haemorrhage is a danger to the patient as it places them at risk of hypovolaemic shock. Additionally, it compromises the visualisation of the nasal and orbital cavities for the endoscopist, particularly when operating on a paediatric patient. This thereby increases the risk of inadvertent damage to anatomical structures such as the anterior ethmoidal artery as well as decreasing the completeness of drainage. Another under-reported complication of endoscopic drainage is that of damage to the medial rectus muscle, optic nerve damage or development of intra-orbital haemorrhage.[90] Although the incidence of ocular complications is low, there is high morbidity associated with it and hence it is important to recognise this. Interestingly, the case of an unresolved diplopia in the Migirov study highlights the possibility of medial rectus muscle damage if there are associated enophthalmos. It is important to note that most of these patients are under the care of an otolaryngological service at the treating hospital, with varying levels of ophthalmological input depending on disease progression. The under-reporting of these complications, which may be due to a small sample size, still gives power to the importance of all patients needing to undergo a full ophthalmological examination by an ophthalmologist post-operatively to assess for any orbital complications. The lack of a clear follow-up period in our included studies also means there is under-reporting of the possible facial skeletal changes in paediatric populations undergoing endoscopic drainage. Although studies by Bothwell[115] and Senior[116] have not demonstrated any effect on facial growth in paediatric patients undergoing endoscopic sinus surgery, conservative surgical resection in children undergoing endoscopic drainage is still advocated.[66, 77, 78] This has been exemplified by Malik[88], who advocates a technique of immediate lamina papyracea reconstruction to maintain and preserve the facial skeleton during endoscopic sinus surgery. Standardising post-operative check-up timeframes and allowing for longer follow-up periods can further address this potential issue.

4.6 Limitations of this review

This review aimed to ascertain if an endoscopic surgical approach for subperiosteal orbital abscesses is superior to traditional external drainage techniques. The review has several limitations, which are discussed below.

4.6.1 Limitations at the study and outcome level

Due to a lack of any pre-existing strong evidence to guide treatment, a variety of surgical drainage options were used. External drainage techniques consisted of inner canthal incisions, external ethmoidectomy, transcaruncular drainage, external drainage via incision and drainage, transcutaneous incision, Lynch incision and lateral eyebrow incisions. Endoscopic approaches similarly varied in terms of the degree of lamina papyracea removed as well as whether both anterior and posterior endoscopic ethmoidectomy were done. A lack of standardisation between surgical techniques made it somewhat difficult to compare these techniques based on the outcomes listed in this review. There were also discrepancies and a lack of standardisation in the commencement time of surgery between the two groups. For example, in the study by Rubin[81], cases of endoscopic drainage were operated upon earlier than external drainage subjects, with 83% of cases operated on admission versus 47%. This is particularly important when looking at the outcomes of total hospitalisation and post-operative stay, which would have been skewed between different surgical groups if they were operated on at different times.

The types of studies retrieved also proved to be a limitation in our review. The lack of any randomised controlled trials or prospective studies limited our evidence base and the ability to derive any conclusive information. The majority of the literature base focused on retrospective analyses of single technique approaches rather than formal controlled studies between the two types thereby making it difficult to conduct a comparative meta-analysis and make conclusions regarding causal relationships.

Often, during the analyses, large confidence intervals were encountered for many of the outcomes measured. This indicates that many of the included studies were underpowered and that larger sample sizes are needed for any statistical differences to be seen. This is a difficult issue to address as the incidence of the disease is low and a minimum of 10 years would be required to collect data. Of our included studies, four studies were from the USA, two from Malaysia, one from Taiwan, one from France and one from Israel. They were however all single centre studies, which decreases the external validity of these studies and their applicability to different socioeconomic populations. One of the limitations associated with retrospective studies is that it is difficult to standardise the number of patients in each arm of the study. As such, many of the studies tended to sway towards reporting one surgical drainage technique over the other, thus reducing the statistical significance of any result identified. Surgical literature has been associated with publication bias, with the tendency that studies with positive findings are published more often than those with negative finding . [117] This could possibly present itself as an issue in endoscopic drainage studies that may be biased towards showing a positive result.

Follow-up times for patient reviews were reported sporadically in the studies and proved to be another limitation of this review. Only four of the studies reported follow-up times with a variance in duration of two to 24 months. This relatively short follow-up time precludes valuable analysis of long-term complications such as facial scar formation for external drainage, and mucocele development and other synechiae for endoscopic drainage.

Complication rates were under-reported, with only three articles commenting on rates of complication. This has been elaborated in Chapter 4.5 and may be correlated with an inadequate follow-up time in many of these studies.

Further limitations of this systematic review included the inability to track individual patients' clinical features and outcomes to assist in the development of recommendations for patient selection for different surgical operative intervention. The precise severity of disease and presentation could not be ascertained for many of these individual cases. As such, this makes the development of any formal guidelines difficult.

4.6.2 Limitations at the review level

Only studies published in English were selected, thereby excluding a possible large body of worldwide literature available in other languages on this topic. Additionally, although we attempted to search across databases, there was a possibility that some evidence might have been missed. To ensure that comparative meta-analyses could be conducted, only studies comparing both endoscopic and external surgical drainage techniques were included. As such, many articles with reasonable sample sizes only describing one technique were excluded. This could have further strengthened our single group analyses of the three surgical drainage techniques and their associated outcomes. Another limitation of this review was the role of potential reporting bias in study publication.

4.7 Strengths of the review

In spite of the limitations of the review, there are several strengths, as described below. The search strategy that was employed allowed for a thorough examination of the available literature across both published data and grey literature. A wide search was conducted yielding over 2000 articles, which were analysed to see if they met inclusion and exclusion criteria. This search strategy was based upon a clear systematic review protocol, which increased both the transparency and reproducibility of the systematic review such that it could be conducted again in the future when the body of literature increases. During the process of data collection, study selection and assessment of methodological quality, two people were involved, which reduced bias that may have arisen from a single-author review. Using standardised critical appraisal instruments from the Joanna Briggs Institute, all studies were evaluated by the two different team members. This allowed for any discrepancies to be dealt with while reducing bias and increasing the quality of the final data that underwent analysis. Another strength of this systematic review was the ability to synthesise data through meta-analysis, thereby allowing for numerical and statistical comparisons between the control, comparators and outcomes.

As this is a topic of ongoing research, this review will certainly need to be updated in the future. With nine included studies, it is the only exhaustive systematic review on this topic that we are aware of.

4.8 Implications for research

There was a lack of high-level evidence on comparisons between endoscopic and external surgical drainage techniques for subperiosteal orbital abscesses. There are no good quality randomised controlled trials available on this topic and this is likely due to ethical issues associated with performing this type of research in surgery. This is made particularly more difficult as the majority of patients experiencing this pathology are children and parents may have hesitation about enrolling their children in various surgical trials. As such, the only available research in this area is retrospective case series. These studies require clearly outlined inclusion and exclusion criteria, with detailed descriptions of surgical techniques and standardisation in techniques as well as timing of the surgery. Additionally, a truly blinded study is difficult as the surgeon is bound to be aware of the technique they are employing and what pathology they need in order to treat. In light of this, it is important to continue to pool more data from retrospective studies. The patients should be followed up over a long-term period (at least two to three years) and this will help in validating complication rates such as facial skeletal changes. Many of the studies we encountered were inadequately powered and thus there needs to be larger sample sizes in future research; this will unfortunately require studies spanning at least 10 years, given the lower incidence of these pathologies. A prospective multi-centred approach would be the preferred method of conducting a future study as it enhances external validity of the results. Standardisation of surgical techniques used as well as collection of key data such as complication rates (eg. Bleeding, abscess recollection, vision damage) and hospital stay (in days) would assist in the assessment of both techniques. This review will continue to require updating in the future as more research is added to the body of evidence.

4.9 Implications for practice

In developed countries, the access to instruments required for endoscopic sinus surgery is widely available, with newer technologies now delivering enhanced image quality of 4K-picture resolution.[118] Developing nations however are only recently gaining access to much of this technology and its access for the general population remains limited.[119] The benefit of this exhaustive review is that ultimately there are very minor differences in outcomes between this newer technological advancement compared to traditional external drainage to suggest that one technique is superior to the other. Patient safety should always be of paramount importance in the decision to choose a particular technique. As such, it is often left to the individual preference of the operating surgeon based on their training, history and skillset as to the technique to be employed. Performing endoscopic drainage in a patient with a subperiosteal abscess incurs some difficulties such as the potential of congested and haemorrhagic mucosa to impair vision, presenting challenges even for the most experienced of endoscopic surgeons.

With regards to rate of recurrence, there was no statistical difference suggesting a benefit of endoscopic drainage over external drainage. However, our comparative meta-analysis for recurrence comparing combined drainage with endoscopic surgery showed a marked difference in recurrence rates despite it not being statistically significant and being heavily underpowered. Given the trend of a lack of any recurrence in the combined drainage group, it may be appropriate to hypothesise that combined drainage results in better abscess clearance than endoscopic drainage. The trend in the literature of cases of recurrence being treated with external or combined drainage as a follow-up operation does suggest that surgeons may be comfortable with external drainage offering more complete abscess clearance than endoscopic drainage. The slightly lower recurrence rate in the comparative meta-analysis between combined drainage and external drainage (RR 0.25, 95% CI 0.05-1.29 $p = 0.10$) indicates that there may be marginal benefit in adding endoscopic drainage to an initial external drainage approach for completion of abscess clearance. Another finding identified from the review is that the majority of recurrences that occurred in abscesses located non-medially (i.e. lateral, superolateral, superior or inferior abscesses) were only treated via a singular mode of drainage. Although, Rahbar's[63] three cases of superior abscesses were successfully drained with a pure external approach, there were failures in both external and endoscopic approaches for drainage of superior, superomedial and superolateral abscesses, as seen in the Dewan[110] and Tanna[65] studies. This would give more validity to the idea that perhaps non-medial abscesses are best treated via a combined approach. Therefore, if a surgeon is choosing to perform an external drainage approach as either a primary procedure or secondary procedure for recurrence, it may be appropriate to perform a combined drainage procedure instead if they are adequately trained to perform endoscopic sinus surgery.

With regards to total length of hospitalisation and post-operative stay, there is statistically significant data in the comparative meta-analyses that external drainage is associated with the shortest hospital stay, followed by endoscopic drainage and then combined drainage. The differences in mean difference however are significantly minimal (i.e. less than one day) and as such this has marginal clinical implications for practice. Single group analyses data, albeit very heterogeneous in nature, shows a difference of at least two days in mean total hospitalisation between combined drainage and either endoscopic or external drainage. As such, it would be safe to say there is minimal clinical implication for the reduction in hospital stay on public health costs by choosing one technique over the other.

The complications encountered in endoscopic or external drainage of subperiosteal orbital abscesses have been under-reported in this review based on descriptions found in the available literature. Although there is little clarity with regards to rates of incidence with particular complications, the fact that it has been identified and described in previous studies means that clinicians should take into the account the particular risks and complications of these various procedures when choosing to employ them on various patients. There is added importance to this, given that this pathology tends to affect children more than adults, with risks such as facial scarring, facial skeletal changes and mucocele development needing to be avoided, given the potential long life span of children.

5 Conclusion

Imminent treatment of subperiosteal orbital abscesses via medical and surgical treatment methods is vital, given the high morbidity associated with the disease. This review identified nine studies (of limited quality) assessing either endoscopic, external or combined surgical drainage techniques for subperiosteal orbital abscesses. Each of these techniques encompasses a various surgical approaches, with some variation. All drainage strategies have acceptable outcomes in relation to recurrence rates, total hospitalisation (days), post-operative stay (days) and complication rate. With cases of lateral, inferior or superior abscess extension, an external or combined approach may prove to limit rates of recurrence. External drainage techniques have also been shown to result in a shorter hospital stay by approximately 1 day, whether this is of clinical significance remains to be debated in the setting of the cosmetic complications that may be associated with it. Each technique has its own described complications and it is difficult to derive rates of complication given severe underreporting within the selected studies. It is important to clinically identify the presence of subperiosteal orbital abscess, organise for an immediate computed tomography scan of the orbit and sinuses, and commence intravenous antibiotics quickly prior to deciding whether surgery is required or not. Ultimately, there is an element of varying skill level involved in surgery and whether a certain surgical approach is taken is based upon the skillset of the surgeon and availability of certain instruments. A prime example of this is the endoscopic drainage of superior abscesses undertaken by Roithmann et al[80] which is a technique that many surgeons would not feel comfortable undertaking despite its potential benefits. As such, this review supports the idea that surgeons should choose the appropriate surgical technique based on what they are comfortable and familiar with, and what would be the safest option for the patient.

6 References

1. Dankbaar JW, van Bemmel AJ, Pameijer FA. Imaging findings of the orbital and intracranial complications of acute bacterial rhinosinusitis. Insights Imaging. 2015;6(5):509-18.
2. Givner LB. Periorbital versus orbital cellulitis. Pediatr Infect Dis J. 2002;21(12):1157-8.
3. Messerklinger W. [Endoscopy technique of the middle nasal meatus (author's transl)]. Arch Otorhinolaryngol. 1978;221(4):297-305.
4. Pereira KD, Mitchell RB, Younis RT, Lazar RH. Management of medial subperiosteal abscess of the orbit in children--a 5 year experience. Int J Pediatr Otorhinolaryngol. 1997;38(3):247-54.
5. Choi C, Johnson T. Surgical Management of Subperiosteal Abscess. In: Yen M, Johnson T, editors. Orbital Cellulitis and Periorbital Infections. Cham, Switzerland: Springer International Publishing; 2017;89-98.
6. Epstein VA, Kern RC. Invasive Fungal Sinusitis and Complications of Rhinosinusitis. 481 Otolaryngol Clin North Am. 2008;41(3):497-524.
7. Fakhri S, Pereira K. Endoscopic management of orbital abscesses. Otolaryngol Clin North Am. 2006;39(5):1037-47, viii.
8. Page EL, Wiatrak BJ. Endoscopic vs external drainage of orbital subperiosteal abscess. Arch Otolaryngol Head Neck Surg. 1996;122(7):737-40.
9. Arjmand EM, Lusk RP, Muntz HR. Pediatric sinusitis and subperiosteal orbital abscess formation: Diagnosis and treatment. Otolaryngol Head Neck Surg. 1993;109(5):886-94.
10. Chow AW, Benninger MS, Brook I, Brozek JL, Goldstein EJ, Hicks LA, et al. IDSA clinical practice guideline for acute bacterial rhinosinusitis in children and adults. Clin Infect Dis. 2012;54(8):e72-e112.
11. Rosenfeld RM. CLINICAL PRACTICE. Acute Sinusitis in Adults. N Engl J Med. 2016;375(10):962-70.
12. Meltzer EO, Hamilos DL. Rhinosinusitis diagnosis and management for the clinician: a synopsis of recent consensus guidelines. Mayo Clin Proc. 2011;86(5):427-43.
13. Johnson JT, Rosen CA.Bailey's Head and Neck surgery - Otolaryngology. 5th ed. Philadelphia: Williams and Wilkins; 2001.
14. Hastan D, Fokkens WJ, Bachert C, Newson RB, Bislimovska J, Bockelbrink A. Chronic rhinosinusitis in Europe - an underestimated disease. A GALEN study. Allergy. 2011;66(9):1216-23.
15. Shi JB, Fu QL, Zhang H, Cheng L, Wang YJ, Zhu DD, et al. Epidemiology of chronic rhinosinusitis: results from a cross-sectional survey in seven Chinese cities. Allergy. 2015;70(5):533-9.
16. Australian Bureau of Statistics. Australian Health Survey: First results, 2011–12 [Internet]. 2012 [cited 15 April 2018]. Cat No: 4364.0.55.001. Available from: www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55.0012011-12?OpenDocument.
17. Cooke G, Valenti L, Glasziou P, Britt H. Common general practice presentations and publication frequency. Aust Fam Physician. 2013;42(1-2):65-8.

18. Bradley PJ, Manning KP, Shaw MD. Brain abscess secondary to paranasal sinusitis. J Laryngol Otol. 1984;98(7):719-25.
19. Brook I. Acute sinusitis in children. Pediatr Clin North Am. 2013;60(2):409-24.
20. Mekhitarian Neto L, Pignatari S, Mitsuda S, Fava AS, Stamm A. Acute sinusitis in children: a retrospective study of orbital complications. Braz J Otorhinolaryngol. 2007;73(1):75-9.
21. Harrison HC. Orbital cellulitis with abscess formation caused by sinusitis. Ann Otol Rhinol Laryngol. 1989;98(4 Pt 1):322.
22. Gutowski WM, Mulbury PE, Hengerer AS, Kido DK. The role of C.T. scans in managing the orbital complications of ethmoiditis. Int J Pediatr Otorhinolaryngol. 1988;15(2):117-28.
23. Weber AL, Mikulis DK. Inflammatory disorders of the paraorbital sinuses and their complications. Radiol Clin North Am. 1987;25(3):615-30.
24. Schramm VL, Myers EN, Kennerdell JS. Orbital complications of acute sinusitis: evaluation, management, and outcome. Otolaryngology. 1978;86(2):ORL221-30.
25. Younis RT, Lazar RH, Bustillo A, Anand VK. Orbital infection as a complication of sinusitis: are diagnostic and treatment trends changing? Ear Nose Throat J. 2002;81(11):771-5.
26. Nageswaran S, Woods CR, Benjamin DK, Jr., Givner LB, Shetty AK. Orbital cellulitis in children. Pediatr Infect Dis J. 2006;25(8):695-9.
27. Christie M, Lincoln M, Uribe T, Fata P, Mukhi S. Imaging of Infected Orbits and Sinuses. In Yen M, Johnson T, editors. Orbital Cellulitis and Periorbital Infections. Cham Switzerland: Springer International Publishing; 2017;35-6.
28. Thakar A, Tandon DA, Thakar MD, Nivsarkar S. Orbital cellulitis revisited. Indian J Otolaryngol Head Neck Surg. 2000;52(3):235-42.
29. Meara DJ. Sinonasal disease and orbital cellulitis in children. Oral Maxillofac Surg Clin North Am. 2012;24(3):487-96.
30. Lee S, Yen MT. Management of preseptal and orbital cellulitis. Saudi J Ophthalmol. 2011;25(1):21-9.
31. Jain A, Rubin PA. Orbital cellulitis in children. Int Ophthalmol Clin. 2001;41(4):71-86.
32. Singh SK, James E, Sabarigirish K, Swami H, Sood T. Bilateral orbital complications of paediatric rhinosinusitis. Med J Armed Forces India. 2014;70(1):68-72.
33. Ferguson MP, McNab AA. Current treatment and outcome in orbital cellulitis. Aust N Z J Ophthalmol. 1999;27(6):375-9.
34. Hornblass A, Herschorn BJ, Stern K, Grimes C. Orbital abscess. Surv Ophthalmol. 1984;29(3):169-78.
35. Barone SR, Aiuto LT. Periorbital and orbital cellulitis in the Haemophilus influenzae vaccine era. J Pediatr Ophthalmol Strabismus. 1997;34(5):293-6.
36. Garcia GH, Harris GJ. Criteria for nonsurgical management of subperiosteal abscess of the orbit: analysis of outcomes 1988-1998. Ophthalmology. 2000;107(8):1454-6; discussion 7-8.
37. Harris GJ. Subperiosteal abscess of the orbit. Age as a factor in the bacteriology and response to treatment. Ophthalmology. 1994;101(3):585-95.

38. Todman MS, Enzer YR. Medical management versus surgical intervention of pediatric orbital cellulitis: the importance of subperiosteal abscess volume as a new criterion. Ophthal Plast Reconstr Surg. 2011;27(4):255-9.
39. Oxford LE, McClay J. Medical and surgical management of subperiosteal orbital abscess secondary to acute sinusitis in children. Int J Pediatr Otorhinolaryngol. 2006;70(11):1853-61.
40. Eviatar E, Lazarovitch T, Gavriel H. The correlation of microbiology growth between subperiosteal orbital abscess and affected sinuses in young children. Am J Rhinol Allergy. 2012;26(6):489-92.
41. Chaudhry IA, Shamsi FA, Elzaridi E, Al-Rashed W, Al-Amri A, Al-Anezi F, et al. Outcome of treated orbital cellulitis in a tertiary eye care center in the middle East. Ophthalmology. 2007;114(2):345-54.
42. Steinkuller PG, Jones DB. Microbial preseptal and orbital cellulitis. In: Tasman W, editor. Foundations of clinical ophthalmology. Philadelphia: Lippincott; 1999;1-8.
43. Botting AM, McIntosh D, Mahadevan M. Paediatric pre- and post-septal peri-orbital infections are different diseases. A retrospective review of 262 cases. Int J Pediatr Otorhinolaryngol. 2008;72(3):377-83.
44. Rudloe TF, Harper MB, Prabhu SP, Rahbar R, Vanderveen D, Kimia AA. Acute periorbital infections: who needs emergent imaging? Pediatrics. 2010;125(4):e719-26.
45. Cornelius RS, Martin J, Wippold FJ, 2nd, Aiken AH, Angtuaco EJ, Berger KL, et al. ACR appropriateness criteria sinonasal disease. J Am Coll Radiol. 2013;10(4):241-6.
46. Ryan JT, Preciado DA, Bauman N, Pena M, Bose S, Zalzal GH, et al. Management of pediatric orbital cellulitis in patients with radiographic findings of subperiosteal abscess. Otolaryngol Head Neck Surg. 2009;140(6):907-11.
47. Eustis HS, Mafee MF, Walton C, et al. MR Imaging and CT of orbital infections and complications in acute rhinosinusitis. Radiol Clin North Am. 1998;36(6):1165-1183. xi.
48. Hubert L. Orbital Infections due to Nasal Sinusitis. NY State J Med. 1937;37:1559-64.
49. Chandler JR, Langenbrunner DJ, Stevens ER. The pathogenesis of orbital complications in acute sinusitis. Laryngoscope. 1970;80(9):1414-28.
50. Krouschnabel E. Orbital apex syndrome due to sinus infection. Laryngoscope. 1974;84(3):353-71.
51. Chaudhry IA, Al-Rashed W, Arat YO. The hot orbit: orbital cellulitis. Middle East Afr J Ophthalmol. 2012;19(1):34-42.
52. Brown CL, Graham SM. Nasal irrigations: good or bad? Curr Opin Otolaryngol Head Neck Surg. 2004;12(1):9-13.
53. Benninger MS, Anon J, Mabry RL. The medical management of rhinosinusitis. Otolaryngol Head Neck Surg. 1997;117(3 Pt 2):S41-9.
54. Mygind N. Effects of corticosteroid therapy in non-allergic rhinosinusitis. Acta Otolaryngol. 1996;116(2):164-6.
55. Fu SY, Su GW, McKinley SH, Yen MT. Cytokine expression in pediatric subperiosteal orbital abscesses. Can J Ophthalmol. 2007;42(6):865-9.
56. Wallwork B, Coman W, Feron F, Mackay-Sim A, Cervin A. Clarithromycin and prednisolone inhibit cytokine production in chronic rhinosinusitis. Laryngoscope. 2002;112(10):1827-30.

57. Rubin SE, Zito J. Orbital sub-periosteal abscess responding to medical therapy. J Pediatr Ophthalmol Strabismus. 1994;31(5):325-6.
58. Cable BB, Wassmuth Z, Mann EA, Hommer D, Connely G, Klem C, et al. The effect of corticosteroids in the treatment of experimental sinusitis. Am J Rhinol. 2000;14(4):217-22.
59. Pushker N, Tejwani LK, Bajaj MS, Khurana S, Velpandian T, Chandra M. Role of oral corticosteroids in orbital cellulitis. Am J Ophthalmol. 2013;156(1):178-83 e1.
60. Ramadan HH. Corticosteroid therapy during endoscopic sinus surgery in children: is there a need for a second look? Arch Otolaryngol Head Neck Surg. 2001;127(2):188-92.
61. Yen MT, Yen KG. Effect of corticosteroids in the acute management of pediatric orbital cellulitis with subperiosteal abscess. Ophthal Plast Reconstr Surg. 2005;21(5):363-6.
62. Souliere CR, Jr., Antoine GA, Martin MP, Blumberg AI, Isaacson G. Selective non-surgical management of subperiosteal abscess of the orbit: computerized tomography and clinical course as indication for surgical drainage. Int J Pediatr Otorhinolaryngol. 1990;19(2):109-19.
63. Rahbar R, Robson CD, Petersen RA, DiCanzio J, Rosbe KW, McGill TJ, et al. Management of orbital subperiosteal abscess in children. Arch Otolaryngol Head Neck Surg. 2001;127(3):281-6.
64. Harris GJ. Subperiosteal abscess of the orbit: older children and adults require aggressive treatment. Ophthal Plast Reconstr Surg. 2001;17(6):395-7.
65. Tanna N, Preciado DA, Clary MS, Choi SS. Surgical treatment of subperiosteal orbital abscess. Arch Otolaryngol Head Neck Surg. 2008;134(7):764-7.
66. Froehlich P, Pransky SM, Fontaine P, Stearns G, Morgon A. Minimal endoscopic approach to subperiosteal orbital abscess. Arch Otolaryngol Head Neck Surg. 1997;123(3):280-2.
67. Migirov L, Yakirevitch A, Bedrin L, Wolf M. Endoscopic sinus surgery for medial orbital subperiosteal abscess in children. J Otolaryngol Head Neck Surg. 2009;38(4):504-8.
68. Kayhan FT, Sayin I, Yazici ZM, Erdur O. Management of orbital subperiosteal abscess. J Craniofac Surg. 2010;21(4):1114-7.
69. Devrim I, Kanra G, Kara A, Cengiz AB, Orhan M, Ceyhan M, et al. Preseptal and orbital cellulitis: 15-year experience with sulbactam ampicillin treatment. Turk J Pediatr. 2008;50(3):214-8.
70. Vairaktaris E, Moschos MM, Vassiliou S, Baltatzis S, Kalimeras E, Avgoustidis D, et al. Orbital cellulitis, orbital subperiosteal and intraorbital abscess: report of three cases and review of the literature. J Craniomaxillofac Surg. 2009;37(3):132-6.
71. Sciarretta V, Macri G, Farneti P, Tenti G, Bordonaro C, Pasquini E. Endoscopic surgery for the treatment of pediatric subperiosteal orbital abscess: a report of 10 cases. Int J Pediatr Otorhinolaryngol. 2009;73(12):1669-72.
72. Huang SF, Lee TJ, Young CK, Wang CN. Comparison of Surgical Approaches of Subperiosteal Abscess in Children. Clin Surg 2016;1:1095.
73. Lim JH, Sardesai MG, Ferreira M, Jr., Moe KS. Transorbital neuroendoscopic management of sinogenic complications involving the frontal

sinus, orbit, and anterior cranial fossa. J Neurol Surg B Skull Base. 2012;73(6):394-400.
74. Lyson T, Sieskiewicz A, Rutkowski R, Kochanowicz J, Rozanska M, Rogowski M, et al. Endoscopic drainage of orbital abscesses aided with intraoperative sonography. Neurol Neurochir Pol. 2014;48(5):315-21.
75. Ikeda K, Oshima T, Suzuki H, Kikuchi T, Suzuki M, Kobayashi T. Surgical treatment of subperiosteal abscess of the orbit: Sendai's ten-year experience. Auris Nasus Larynx. 2003;30(3):259-62.
76. Schick U, Hassler W. Neurosurgical management of orbital inflammations and infections. Acta Neurochir (Wien). 2004;146(6):571-80; discussion 80.
77. Eviatar E, Kessler A, Pitaro K. Bidirectional orbital approach enhances orbital abscess drainage. Rhinology. 2009;47(3):293-6.
78. Gavriel H, Kessler A, Eviatar E. Management implications of diagnosing orbital abscess as subperiosteal orbital abscess. Rhinology. 2010;48(1):90-4.
79. Mann W, Amedee RG, Maurer J. Orbital complications of pediatric sinusitis: treatment of periorbital abscess. Am J Rhinol. 1997;11(2):149-53.
80. Roithmann R, Uren B, Pater J, Wormald PJ. Endoscopic drainage of a superiorly based subperiosteal orbital abscess. Laryngoscope. 2008;118(1):162-4.
81. Rubin F, Pierrot S, Lebreton M, Contencin P, Couloigner V. Drainage of subperiosteal orbital abscesses complicating pediatric ethmoiditis: comparison between external and transnasal approaches. Int J Pediatr Otorhinolaryngol. 2013;77(5):796-802.
82. Baring DE, Hilmi OJ. An evidence based review of periorbital cellulitis. Clin Otolaryngol. 2011;36(1):57-64.
83. Cheng J, Liu B, Farjat AE, Jang DW. Adverse Events in Endoscopic Sinus Surgery for Infectious Orbital Complications of Sinusitis: 30-Day NSQIP Pediatric Outcomes. Otolaryngol Head Neck Surg. 2017;157(4):716-21.
84. Bhargava D, Sankhla D, Ganesan A, Chand P. Endoscopic sinus surgery for orbital subperiosteal abscess secondary to sinusitis. Rhinology. 2001;39(3):151-5.
85. Stammberger H, Posawetz W. Functional endoscopic sinus surgery. Concept, indications and results of the Messerklinger technique. Eur Arch Otorhinolaryngol. 1990;247(2):63-76.
86. Lusk RP. Endoscopic approach to sinus disease. J Allergy Clin Immunol. 1992;90(3 Pt 2):496-505.
87. Manning SC. Endoscopic management of medial subperiosteal orbital abscess. Arch Otolaryngol Head Neck Surg. 1993;119(7):789-91.
88. Malik V, Khwaja S, De Carpentier J. Immediate lamina papyracea reconstruction during endoscopic sinus surgery for surgically managed subperiosteal abscess in children. Laryngoscope. 2006;116(5):835-8.
89. Graham SM, Nerad JA. Orbital complications in endoscopic sinus surgery using powered instrumentation. Laryngoscope. 2003;113(5):874-8.
90. Rene C, Rose GE, Lenthall R, Moseley I. Major orbital complications of endoscopic sinus surgery. Br J Ophthalmol. 2001;85(5):598-603.
91. Noordzij JP, Harrison SE, Mason JC, Hashisaki GT, Reibel JF, Gross CW. Pitfalls in the endoscopic drainage of subperiosteal orbital abscesses secondary to sinusitis. Am J Rhinol. 2002;16(2):97-101.

92. Cavaliere M, Volino F, Parente G, Troisi S, Iemma M. [Endoscopic treatment of orbital cellulitis in pediatric patients: transethmoidal approach]. Arch Soc Esp Oftalmol. 2013;88(7):271-5. Spanish
93. Sackett DL. Evidence-based medicine and treatment choices. Lancet. 1997;349(9051):570; author reply 2-3.
94. Masic I, Miokovic M, Muhamedagic B. Evidence based medicine - new approaches and challenges. Acta Inform Med. 2008;16(4):219-25.
95. Abbas Z, Raza S, Ejaz K. Systematic reviews and their role in evidence-informed health care. J Pak Med Assoc. 2008;58(10):561-7.
96. Jordan Z, Lockwood C, Aromataris E, Munn Z. The updated JBI model for evidence-based healthcare. Joanna Briggs Institute. [internet] 2016. [cited 28.09.18]. Available from: http://joannabriggs.org/jbi-approach.html
97. Tufanaru C, Munn Z, Stephenson M, Aromataris E. Fixed or random effects meta-analysis? Common methodological issues in systematic reviews of effectiveness. Int J Evid Based Healthc. 2015;13(3):196-207.
98. Munn Z, Tufanaru C, Aromataris E. JBI's systematic reviews: data extraction and synthesis. Am J Nurs. 2014;114(7):49-54.
99. Sekhar V, Ao J, Iqbal I, Ooi EH, Munn Z. Effectiveness of endoscopic versus external surgical approaches in the treatment of orbital complications of rhinosinusitis: a systematic review protocol. JBI Database System Rev Implement Rep. 2019. Nov;17(11):2378-2389.
100. Tufanaru C, Munn Z, Aromatis E, Campbell J, Hopp L. Chapter 3: Systematic reviews of effectiveness. In: Aromatis E, Munn, editors. Joanna Briggs Institute Reviewer's Manual. The Joanna Briggs Institute. [internet] 2017. [cited 28.09.18]. Available from: https://reviewsmanual.joannabriggs.org/
101. Munn Z, Aromataris E, Tufanaru C, Stern C, Porritt K, Farrow J, et al. The development of software to support multiple systematic review types: the Joanna Briggs Institute System for the Unified Management, Assessment and Review of Information (JBI SUMARI). Int J Evid Based Healthc. 2019;17(1):36-43.
102. Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, et al. Chapter 7: Systematic reviews of etiology and risk 2017. In: Joanna Briggs Institute Reviewer's Manual [Internet]. The Joanna Briggs Institute. [internet] 2017. [cited 28.09.18]. Available from https://reviewersmanual.joannabriggs.org/.
103. Wallace BC DI, Trikalinos TA, Lau J, Trow P, Schmid CH. OpenMeta[Analyst]: Closing the Gap between Methodologists and End-Users: R as a Computational Back-End. Journal of Statistical Software 2012.
104. Centre TNC. Review Manager (RevMan). 5.3 ed. Copenhagen: The Cochrane Collaboration; 2014.
105. Ltd S. StatsDirect statistical software. In: Ltd S, editor. England: StatsDirect Ltd; 2013.
106. Munn Z, Moola S, Lisy K, Riitano D, Tufanaru C. Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. Int J Evid Based Healthc. 2015;13(3):147-53.
107. Kelley GA, Kelley KS. Statistical models for meta-analysis: A brief tutorial. World J Methodol. 2012;2(4):27-32.

108. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Int J Surg. 2010;8(5):336-41.
109. Pelton RW, Smith ME, Patel BCK, Kelly SM. Cosmetic considerations in surgery for orbital subperiosteal abscess in children: Experience with a combined transcaruncular and transnasal endoscopic approach. Arch Otolaryngol Head Neck Surg. 2003;129(6):652-5.
110. Dewan MA, Meyer DR, Wladis EJ. Orbital cellulitis with subperiosteal abscess: Demographics and management outcomes. Ophthalmic Plastic and Reconstructive Surgery. 2011;27(5):330-2.
111. Suhaili DN, Goh BS, Gendeh BS. A ten year retrospective review of orbital complications secondary to acute sinusitis in children. Med J Malaysia. 2010;65(1):49-52.
112. Hassan E, Gendeh BS, Husain S, Faizah MZ. Orbital complications secondary to acute sinusitis– A 10 years retrospective review. Eastern Journal of Medicine. 2014;19:130-6.
113. Higgins JPT GS. Cochrane Handbook for Systematic Reviews of Interventions [intenet]. 2011 [cited 30.11.18 Available from: https://handbook-51.cochrane.org/chapter_7/7_7_extracting_study_results_and_converting_to_the_desired.htm.
114. Khalifa BC. Extent of resection of the lamina papyracea in medial subperiosteal abscess. Otolaryngol Head Neck Surg. 2011;145(1):161-4.
115. Bothwell MR, Piccirillo JF, Lusk RP, Ridenour BD. Long-term outcome of facial growth after functional endoscopic sinus surgery. Otolaryngol Head Neck Surg. 2002;126(6):628-34.
116. Senior B, Wirtschafter A, Mai C, Becker C, Belenky W. Quantitative impact of pediatric sinus surgery on facial growth. Laryngoscope. 2000;110(11):1866-70.
117. Ross A, Cooper C, Gray H, Umberham B, Vassar M. Assessment of Publication Bias and Systematic Review Findings in Top-Ranked Otolaryngology Journals. JAMA Otolaryngol Head Neck Surg. 2018.
118. Rigante M, La Rocca G, Lauretti L, D'Alessandris GQ, Mangiola A, Anile C, et al. Preliminary experience with 4K ultra-high definition endoscope: analysis of pros and cons in skull base surgery. Acta Otorhinolaryngol Ital. 2017;37(3):237-41.
119. Rai D, Munjal M, Rai V. Navigation in endoscopic sinus surgery: the first Indian experience. Indian J Otolaryngol Head Neck Surg. 2013;65(Suppl 2):394-9.

7 Appendices

7.1 Appendix 1: Search strategy

Search conducted on 17thrd February 2019.

PubMed

Search	Query	Records retrieved
#1	Orbital Cellulitis[mh] OR Orbital Celluliti*[tw] OR Orbital abscess*[tw] OR post septal celluliti*[tw] OR postseptal celluliti*[tw] OR post-septal cellulit*[tw] OR subperiosteal abscess*[tw] OR sub periosteal abscess*[tw] OR sub-periosteal abscess*[tw] OR SPA[tw] OR SPAs[tw] OR SPA's[tw] OR subperiosteal orbital[tw] OR sub periosteal orbital[tw] OR sub-periosteal orbital[tw] OR SPOA*[tw] OR Cavernous Sinus Thrombosis[mh] OR Cavernous Sinus Thrombos*[tw] OR Cavernous Sinus Septic Phlebitis[tw] OR Cavernous Sinus Thrombophlebiti*[tw] OR cavernous sinus syndrome*[tw] OR foix syndrome[tw]	11,376
#2	Endoscopic drainage[tw] OR endoscopic approach[tw] OR endoscopic technique[tw] OR endoscopic procedure[tw] or endoscopic surgery[tw] OR endoscopic sinus surgery[tw] OR ESS[tw] or Functional endoscopic sinus surgery[tw] OR FESS[tw] OR Endoscopy[mh] OR endoscopy[tw] OR surgical endoscopy[tw] OR endoscopic surgical procedure*[tw] OR nasal endoscop*[tw] OR transnasal endoscop*[tw] OR trans nasal endoscop*[tw] OR trans-nasal endoscop* OR TNE[tw] OR transnasal endoscopy sinus surgery[tw] OR trans nasal endoscopic sinus surgery[tw] OR trans-nasal endoscopic sinus surgery[tw] OR maxillary antrostomy[tw] OR endoscopic ethmoidectomy[tw] OR transnasal ethmoidectomy[tw] OR trans nasal ethmoidectomy[tw] OR trans-nasal ethmoidectomy[tw] OR endoscopic frontal sinusotomy[tw]	**316,624**

	OR Draf*[tw] or Modified Lothrop procedure OR endonasal drainage[tw] OR endonasal approach[tw] OR endonasal method[tw] OR endonasal technique[tw] OR endonasal procedure[tw] OR endonasal surgery[tw] OR endo nasal approach[tw] OR endo nasal method[tw] OR endo nasal technique[tw] OR endo nasal procedure[tw] OR endo nasal surgery[tw] OR endo-nasal approach[tw] OR endo-nasal method[tw] OR endo-nasal technique[tw] OR endo-nasal procedure[tw] OR endo-nasal surgery[tw]	
#3	External drainage[tw] OR external approach[tw] OR external incision[tw] OR external procedure[tw] OR external technique[tw] OR external method[tw] OR external surgery[tw] OR open drainage[tw] OR open approach[tw] OR open incision[tw] OR open procedure[tw] OR open technique[tw] OR open method[tw] or open surgery[tw] OR extranasal ethmoidectomy[tw] OR extra nasal ethmoidectomy[tw] OR extra-nasal ethmoidectomy[tw] OR external ethmoidectomy[tw] OR external frontoethmoidectomy[tw] OR classic external frontoethmoidectomy[tw] OR radical external frontoethmoidectomy[tw] OR open frontoethmoidectomy[tw] OR open ethmoidectomy[tw] OR external fronto-ethmoidectomy[tw] OR classic external fronto-ethmoidectomy[tw] OR radical external fronto-ethmoidectomy[tw] OR open fronto-ethmoidectomy[tw] OR Lynch-Howarth[tw] OR Lynch Howarth[tw] OR Lynch and Howarth[tw] OR Lynch[tw] OR Caldwell-luc[tw] OR Caldwell luc[tw] OR intra-oral antrostomy[tw] OR intraoral antrostomy[tw] OR intra oral antrostomy[tw] OR external antrostomy[tw] OR open antrostomy[tw] OR radical antrostomy[tw] OR transcaruncular[tw] OR trans-caruncular[tw] OR orbitotomy[tw] OR canthotomy[tw] OR cantholysis[tw] OR Moore's[tw] OR Moure's[tw] OR frontal sinus trephin*[tw] OR frontal trephin*[tw] OR external frontal sinusotomy[tw] OR lateral sub-brow[tw] OR lateral subbrow[tw] OR sub-brow[tw] OR subbrow[tw] OR subciliary[tw] OR sub-ciliary[tw] OR superolateral brow[tw] OR supero-lateral brow[tw] OR transcutaneous[tw] OR trans-	57,370

	cutaneous[tw] OR transconjuctival[tw] OR trans-conjuctival[tw] OR inferior transconjuctival[tw] OR inferior trans-conjuctival[tw] OR transverse eyebrow[tw] OR bifrontal[tw] OR bi-frontal[tw] OR rhinotomy[tw] OR Macbeth procedure[tw] OR bircronal osteoplastic flap[tw] OR Patterson trans-orbital[tw] OR Patterson transorbital[tw] OR trans-antral[tw] OR transantral[tw] OR Jansen-Horgen[tw] OR jansen Horgen[tw] OR bicronal[tw] OR bi-cronal[tw] OR open sky[tw] OR gullwing[tw] OR butterfly[tw] OR sewali[tw] OR riedel[tw] OR killian[tw] OR killian's[tw]	
#4	#1 AND #2	299
#5	#1 AND #3	157
Limited to English		

7.2 Appendix 2: JBI SUMARI appraisal instrument

JBI Critical Appraisal Checklist for Case Series

Reviewer____Date_____________

Author ____Year___________

Record number ________

	Yes	No	Unclear	Not applicable
Were there clear criteria for inclusion in the case series?	□	□	□	□
Was the condition measured in a standard, reliable way for all participants included in the case series?	□	□	□	□
Were valid methods used for identification of the condition for all participants included in the case series?	□	□	□	□
Did the case series have consecutive inclusion of participants?	□	□	□	□
Did the case series have complete inclusion of participants?	□	□	□	□
Was there clear reporting of the demographics of the participants in the study?	□	□	□	□
Was there clear reporting of clinical information of the participants?	□	□	□	□
Were the outcomes or follow up results of	□	□	□	□

cases clearly reported?				
Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	☐	☐	☐	☐
Was statistical analysis appropriate?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Comments (Including reason for exclusion)

____

7.3 Appendix 3: Excluded studies and reasons for their exclusion

7.3.1 Only one technique described/unclear technique

1. Yang M, Quah BL, Seah LL, Looi A. Orbital cellulitis in children-medical treatment versus surgical management. Orbit. 2009;28(2-3):124-36.
2. Soon VTE. Pediatric subperiosteal orbital abscess secondary to acute sinusitis: A 5-year review. American Journal of Otolaryngology - Head and Neck Medicine and Surgery. 2011;32(1):62-8.
3. Zeccardo E, Cavaliere M. Orbitaria cellulitis treatment in paediatric patients: Transethmoidal approach. European Surgical Research. 2012;49(3-4):199.
4. Younis RT. Endoscopic drainage of subperiosteal abscess in children: A pilot study. American Journal of Rhinology. 1996;10(1):11-5.
5. Thakar A, Tandon DA, Thakar MD, Nivsarkar S. Orbital cellulitis revisited. Indian J Otolaryngol Head Neck Surg. 2000;52(3):235-42.
6. Thakur JS, Mohindroo NK, Sharma DR, Arora R. Transnasal endoscopic surgery in retro-orbital abscess. Clinical Rhinology. 2012;5(1):14-6
7. Teinzer F, Stammberger H, Tomazic PV. Transnasal endoscopic treatment of orbital complications of acute sinusitis: the Graz concept. Ann Otol Rhinol Laryngol. 2015;124(5):368-73
8. Souliere CR, Jr., Antoine GA, Martin MP, Blumberg AI, Isaacson G. Selective non-surgical management of subperiosteal abscess of the orbit: computerized tomography and clinical course as indication for surgical drainage. Int J Pediatr Otorhinolaryngol. 1990;19(2):109-19.
9. Smith JM, Bratton EM, Dewitt P, Davies BW, Hink EM, Durairaj VD. Predicting the need for surgical intervention in pediatric orbital cellulitis. American Journal of Ophthalmology. 2014;158(2):387-94.e1.
10. Sciarretta V, Macri G, Farneti P, Tenti G, Bordonaro C, Pasquini E. Endoscopic surgery for the treatment of pediatric subperiosteal orbital abscess: a report of 10 cases. Int J Pediatr Otorhinolaryngol. 2009;73(12):1669-72.
11. Sciarretta V, Demattè M, Farneti P, Fornaciari M, Corsini I, Piccin O, et al. Management of orbital cellulitis and subperiosteal orbital abscess in pediatric patients: A ten-year review. International Journal of Pediatric Otorhinolaryngology. 2017;96:72-6.
12. Samad I, Riding K. Orbital complications of ethmoiditis: B.C. Children's Hospital experience, 1982-89. Journal of Otolaryngology. 1991;20(6):400-3.
13. Radovani P, Vasili D, Xhelili M, Dervishi J. Orbital complications of sinusitis. Balkan Medical Journal. 2013;30(2):151-4.
14. Quick CA, Payne E. Complicated acute sinusitis. Laryngoscope. 1972;82(7):1248-63.
15. Pool C, McGinn J. Endoscopic management of subperiosteal abscesses. Operative Techniques in Otolaryngology - Head & Neck Surgery. 2018;29(4):222-5.
16. Pereira KD, Mitchell RB, Younis RT, Lazar RH. Management of medial subperiosteal abscess of the orbit in children--a 5 year experience. Int J Pediatr Otorhinolaryngol. 1997;38(3):247-54

17. Noordzij JP, Harrison SE, Mason JC, Hashisaki GT, Reibel JF, Gross CW. Pitfalls in the endoscopic drainage of subperiosteal orbital abscesses secondary to sinusitis. Am J Rhinol. 2002;16(2):97-101.
18. Manning SC. Endoscopic management of medial subperiosteal orbital abscess. Archives of Otolaryngology - Head and Neck Surgery. 1993;119(7):789-91.
19. Manning SC. Endoscopic drainage of subperiosteal orbital abscesses. Operative Techniques in Otolaryngology - Head and Neck Surgery. 2002;13(1):73-6.
20. Lize F, Verillaud B, Vironneau P, Blancal JP, Guichard JP, Kania R, et al. Septic cavernous sinus thrombosis secondary to acute bacterial sinusitis: a retrospective study of seven cases. American journal of rhinology & allergy. 2015;29(1):e7-12.
21. Lin CY, Chiu NC, Lee KS, Huang FY, Hsu CH. Neonatal orbital abscess. Pediatrics international : official journal of the Japan Pediatric Society. 2013;55(3):e63-6.
22. Lim JH, Sardesai MG, Ferreira M, Jr., Moe KS. Transorbital neuroendoscopic management of sinogenic complications involving the frontal sinus, orbit, and anterior cranial fossa. J Neurol Surg B Skull Base. 2012;73(6):394-400.
23. Kong MH, Jemaima CH, Rona AN, Balwant SG. Endoscopic drainage of superior subperiosteal orbital abscess. Eastern Journal of Medicine. 2014;19:194-7.
24. Kinis V, Ozbay M, Bakir S, Yorgancilar E, Gun R, Akdag M, et al. Management of orbital complications of sinusitis in pediatric patients. J Craniofac Surg. 2013;24(5):1706-10.
25. Kim JH, Kim SH, Song CI, Kang JW. Image-guided nasal endoscopic drainage of an orbital superior subperiosteal abscess. British Journal of Oral and Maxillofacial Surgery. 2016;54(2):e26-e8.
26. Khalifa BC. Extent of resection of the lamina papyracea in medial subperiosteal abscess. Otolaryngology-Head & Neck Surgery. 2011;145(1):161-4.
27. Graham SM, Thomas RD, Carter KD, Nerad JA. The transcaruncular approach to the medial orbital wall. Laryngoscope. 2002;112(6):986-9.
28. Gavriel H, Kessler A, Eviatar E. Management implications of diagnosing orbital abscess as subperiosteal orbital abscess. Rhinology. 2010;48(1):90-4.
29. Gavriel H, Jabrin B, Eviatar E. Management of superior subperiosteal orbital abscess. European Archives of Oto-Rhino-Laryngology. 2016;273(1):145-50.
30. Froehlich P, Pransky SM, Fontaine P, Stearns G, Morgon A. Minimal endoscopic approach to subperiosteal orbital abscess. Arch Otolaryngol Head Neck Surg. 1997;123(3):280-2.
31. Fakhri S. Endoscopic drainage of subperiosteal orbital abscesses. Operative Techniques in Otolaryngology - Head & Neck Surgery. 2008;19(3):195-8.
32. Fakhri S, Pereira K. Endoscopic management of orbital abscesses. Otolaryngol Clin North Am. 2006;39(5):1037-47, viii.
33. Eviatar E, Kessler A, Pitaro K. Bidirectional orbital approach enhances orbital abscess drainage. Rhinology. 2009;47(3):293-6.
34. Elverland HH, Melheim I, Anke IM. Acute orbit from ethmoiditis drained by endoscopic sinus surgery. Acta Oto-Laryngologica, Supplement. 1992(492):147-51.

35. el-Silimy O. The place of endonasal endoscopy in the treatment of orbital cellulitis. Rhinology. 1995;33(2):93-6.
36. Deutsch E, Eilon A, Hevron I, Hurvitz H, Blinder G. Functional endoscopic sinus surgery of orbital subperiosteal abscess in children. International Journal of Pediatric Otorhinolaryngology. 1996;34(1-2):181-90.
37. Chan JCW, Yu DKH, Lee DLY, Abdullah VJ, Li KKW. Combined lateral orbitotomy and endoscopic transnasal orbital decompression in a case of orbital aspergillosis with impending intracranial invasion. Case Reports in Ophthalmology. 2012;3(3):418-23.
38. Casiano RR, Livingston JA. Endoscopic Lothrop procedure: the University of Miami experience. Am J Rhinol. 1998;12(5):335-9.
39. Bradoo R, Potdar N, Joshi A, Shah K, Modi R, Shinde C. Transcutaneous Endoscopic Orbital Surgery: A Less Morbid Alternative to Lateral Orbitotomy. Orbit. 2015;34(1):1-5.
40. Bhargava D, Sankhla D, Ganesan A, Chand P. Endoscopic sinus surgery for orbital subperiosteal abscess secondary to sinusitis. Rhinology. 2001;39(3):151-5.
41. Friling R, Garty BZ, Kornreich L, Scheurman O, Hasanreisoglu M, Taler I, et al. Medical And Surgical Management Of Orbital Cellulitis In Children. Folia medica. 2014;56(4):253-8.
42. Cheng J, Liu B, Farjat AE, Jang DW. Adverse Events in Endoscopic Sinus Surgery for Infectious Orbital Complications of Sinusitis: 30-Day NSQIP Pediatric Outcomes. Otolaryngol Head Neck Surg. 2017;157(4):716-21.

7.3.2 Mucocele present

1. Page EL, Wiatrak BJ. Endoscopic vs external drainage of orbital subperiosteal abscess. Arch Otolaryngol Head Neck Surg. 1996;122(7):737-40.
2. Arjmand EM, Lusk RP, Muntz HR. Pediatric sinusitis and subperiosteal orbital abscess formation: Diagnosis and treatment. Otolaryngology - Head and Neck Surgery. 1993;109(5):886-94.

7.3.3 Outcomes not reported

1. Younis RT, Lazar RH, Bustillo A, Anand VK. Orbital infection as a complication of sinusitis: are diagnostic and treatment trends changing? Ear Nose Throat J. 2002;81(11):771-5.
2. Wong SJ, Levi J. Management of pediatric orbital cellulitis: A systematic review. International Journal of Pediatric Otorhinolaryngology. 2018;110:123-9.
3. Van der Veer EG, van der Poel NA, de Win MML, Kloos RJ, Saeed P, Mourits MP. True abscess formation is rare in bacterial orbital cellulitis; consequences for treatment. American Journal of Otolaryngology - Head and Neck Medicine and Surgery. 2017;38(2):130-4

4. Upile NS, Munir N, Leong SC, Swift AC. Who should manage acute periorbital cellulitis in children? International Journal of Pediatric Otorhinolaryngology. 2012;76(8):1073-7.
5. Tabarino F, Elmaleh-Bergès M, Quesnel S, Lorrot M, Van Den Abbeele T, Teissier N. Subperiosteal orbital abscess: Volumetric criteria for surgical drainage. International Journal of Pediatric Otorhinolaryngology. 2015;79(2):131-5.
6. Smith DM, Vossough A, Vorona GA, Beslow LA, Ichord RN, Licht DJ. Pediatric cavernous sinus thrombosis. Neurology. 2015;85(9):763-9.
7. Siedek V, Kremer A, Betz CS, Tschiesner U, Berghaus A, Leunig A. Management of orbital complications due to rhinosinusitis. European archives of oto-rhino-laryngology : official journal of the European Federation of Oto-Rhino-Laryngological Societies (EUFOS) : affiliated with the German Society for Oto-Rhino-Laryngology - Head and Neck Surgery. 2010;267(12):1881-6.
8. Sharma S, Josephson GD. Orbital complications of acute sinusitis in infants: a systematic review and report of a case. JAMA otolaryngology-- head & neck surgery. 2014;140(11):1070-3.
9. Ryan JT, Preciado DA, Bauman N, Pena M, Bose S, Zalzal GH, et al. Management of pediatric orbital cellulitis in patients with radiographic findings of subperiosteal abscess. Otolaryngol Head Neck Surg. 2009;140(6):907-11
10. Ozkurt FE, Ozkurt ZG, Gul A, Akdag M, Sengul E, Yilmaz B, et al. Managment of orbital complications of sinusitis. Arquivos brasileiros de oftalmologia. 2014;77(5):293-6.
11. Liang KL, Su MC, Shiao JY, Hsin CH, Jiang RS. Endoscopic sinus surgery for the management of orbital diseases. ORL; journal for oto-rhino-laryngology and its related specialties. 2008;70(2):134-40.
12. Ketenci I, Unlu Y, Vural A, Dogan H, Sahin MI, Tuncer E. Approaches to subperiosteal orbital abscesses. European archives of oto-rhino-laryngology : official journal of the European Federation of Oto-Rhino-Laryngological Societies (EUFOS) : affiliated with the German Society for Oto-Rhino-Laryngology - Head and Neck Surgery. 2013;270(4):1317-27.
13. Kessler A, Berenholz LP, Segal S. Transnasal endoscopic drainage of a medial subperiosteal orbital abscess. European Archives of Oto-Rhino-Laryngology. 1998;255(6):293-5.
14. Ikeda K, Oshima T, Suzuki H, Kikuchi T, Suzuki M, Kobayashi T. Surgical treatment of subperiosteal abscess of the orbit: Sendai's ten-year experience. Auris Nasus Larynx. 2003;30(3):259-62.
15. Holý R, Koviṗ D, Fundovś P, Belšan T, Filipovský T, Astl J. Orbital cellulitis as a complication of acute rhinosinusitis - Our experience with treatment in adult patients. Ceska a Slovenska Neurologie a Neurochirurgie. 2016;79(6):698-702.
16. Flam JO, Platt MP, Sobel R, Devaiah AK, Brook CD. Association of oral flora with orbital complications of acute sinusitis. American Journal of Rhinology and Allergy. 2016;30(4):257-60.
17. Erickson BP, Lee WW. Orbital cellulitis and subperiosteal abscess: A 5-year outcomes analysis. Orbit. 2015;34(3):115-20.

18. Chai-Lee T, Nadarajah S, Abdullah B, Mohamad I, Maruthamuthu T, Nadarajan C, et al. Image-guided system endoscopic drainage of orbital abscess caused by methicillin-resistant Staphylococcus aureus in an infant. International journal of surgery case reports. 2017;33:119-23.
19. Yoon TM, Kim K, Lim SC. Visual outcome after endoscopic decompression surgery for sphenoid sinus disease: How we do it. Clinical Otolaryngology. 2008;33(5):480-1
20. Wan Y, Shi G, Wang H. Treatment of Orbital Complications Following Acute Rhinosinusitis in Children. Balkan Med J. 2016;33(4):401-6.
21. Singh B. The management of sinogenic orbital complications. Journal of Laryngology and Otology. 1995;109(4):300-3.
22. Roithmann R, Uren B, Pater J, Wormald PJ. Endoscopic drainage of a superiorly based subperiosteal orbital abscess. Laryngoscope. 2008;118(1):162-4.
23. Richtsmeier WJ. Medical and surgical management of sinusitis in adults. The Annals of otology, rhinology & laryngology Supplement. 1992;155:46-50.
24. Kayhan FT, Sayin I, Yazici ZM, Erdur O. Management of orbital subperiosteal abscess. J Craniofac Surg. 2010;21(4):1114-7.
25. Jackson LL, Kountakis SE. Classification and management of rhinosinusitis and its complications. Otolaryngologic Clinics of North America. 2005;38(6):1143-53.
26. Ismi O, Vayisoğlu Y, Bal KK, Helvaci I, Görür K, Ozcan C. Surgical Treatment of Rhinosinusitis-Related Orbital Complications: Factors Affecting Irreversible Blindness. Journal of Craniofacial Surgery. 2018;29(5):1294-9.
27. Flis DW, Vecchiotti MA, Scott AR. The safety and feasibility of extended endonasal approaches to orbital cellulitis in infants and toddlers. Journal of Neurological Surgery, Part B: Skull Base. 2013;74
28. Fatakia A, Guarisco JL. Management of superiorly based subperiosteal orbital abscess. Laryngoscope. 2011;121(SUPPL. 4).
29. Campolattaro BN, Lueder GT, Tychsen L. Spectrum of pediatric dacryocystitis: Medical and surgical management of 54 cases. Journal of Pediatric Ophthalmology and Strabismus. 1997;34(3):143-53.
30. Branson SV, McClintic E, Yeatts RP. Septic Cavernous Sinus Thrombosis Associated With Orbital Cellulitis: A Report of 6 Cases and Review of Literature. Ophthalmic Plast Reconstr Surg. 2018.
31. Bedwell J, Bauman NM. Management of pediatric orbital cellulitis and abscess. Curr Opin Otolaryngol Head Neck Surg. 2011;19(6):467-73.