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MAIN ARTICLE

Paediatric orbital cellulitis and the relationship to underlying sinonasal anatomy on computed tomography

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Abstract

Objective: To assess if there is an association between sinonasal anatomical variants and the risk of developing orbital cellulitis and associated complications, in children.

Methods: A retrospective case–control series was conducted, examining computed tomography confirmed sinonasal anatomical variants of septal deviation and concha bullosa in children who presented with periorbital cellulitis who went on to develop orbital cellulitis and abscesses.

Results: Thirty children had a Chandler score of 2 or greater on computed tomography. Mean age was seven years and there was relatively equal sex distribution. There was no association between presence of concha bullosa and side of disease (odds ratio = 1), and no statistically significant difference between septal deviation and ipsilateral orbital infection ($p = 0.125$).

Conclusion: There was no statistical correlation between any sinonasal bony or cartilaginous anatomical variants on computed tomography and orbital complications of acute rhinosinusitis in our paediatric cohort. The findings do not support the theory that these anatomical variants predispose to orbital cellulitis occurring in these children, nor complications thereof.

Key words: Child; Sinusitis; Orbital Cellulitis; Paranasal Sinuses; Computed Tomography; X-Ray

Introduction

Periorbital cellulitis is a relatively common paediatric ENT emergency. In our catchment area, the incidence of admission for children with this condition is approximately 1:3400 per annum.[1,2] Clinically, the most important characterisation is between pre-septal and post-septal involvement, typically determined by assessment of visual acuity, colour vision, pupillary reactions, ocular mobility, skin sensation and general examination of the child. The vast majority of children will have evidence of pre-septal infection, and will be treated conservatively with antibiotics (either oral or intravenous), topical nasal decongestants and ophthalmological assessment, certainly initially. The more serious post-septal infections often require surgical drainage.

The most common classification method is the Chandler system, which characterises infections as pre-septal, orbital cellulitis, subperiosteal abscess, orbital abscess and cavernous sinus thrombosis.[3] This classification is based on the computed tomography (CT) findings.

In the paediatric population, it can be difficult to accurately differentiate the 'common cold' or viral upper respiratory tract infection (URTI) from acute rhinosinusitis, certainly at the early stages of symptom onset. In reality, these are closely interlinked conditions and nomenclature, which are reportedly differentiated predominantly on the length of symptom duration, with signs of clinical improvement between 7 and 12 days following onset in URTI, and persistent symptom duration lasting longer than 10 days in acute rhinosinusitis.[4] Bacterial rhinosinusitis is thought to develop on the background of an URTI, or any acute inflammation of the nasal and sinus mucosa, which leads to natural sinus ostia obstruction, ciliary impairment and, thus, accumulation of secretions within sinuses; secondary infection from commensal bacteria can then develop.[5]

The subsequent spread of infection or inflammation to involve the orbit has multiple proposed anatomical routes. These include direct spread through the thin or dehiscent lamina papyracea from the

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ethmoid sinuses, through the foramina of the anterior or posterior ethmoid arteries, or via the valve-less venous network which closely connects the orbit with the maxillary and ethmoid sinuses, along with cavernous sinus and eyelids.[6] It has been previously reported that intracranial complications are more likely to evolve from acute frontal sinusitis, particularly meningitis, cerebritis, subdural or epidural empyema, intracranial abscesses, and cavernous sinus thrombosis.[7]

The presence of anatomical variants in adult patients being investigated for chronic rhinosinusitis has been established, particularly septal deviation.[8,9] However, there is limited literature regarding the incidence and importance of paediatric nasal anatomical variants in those children who develop orbital complications of acute rhinosinusitis.[10,11]

We found the apparent randomness of the side affected interesting. Upper respiratory tract infections are very common in young children, but they only occasionally lead to infection spreading into the orbit. Why this should occur in some children but not others is unclear. We postulated that such spread is more likely in the presence of bony anatomical abnormalities in the nose, leading to poor sinus drainage. This study aimed to determine if there were any obvious underlying sinonasal anatomical variants, visible on CT, which correlated with the side affected by orbital cellulitis.

Materials and methods

A retrospective case note review was undertaken for all children who underwent orbital CT for investigation of periorbital cellulitis between January 2012 and January 2016 at the Royal Hospital for Sick Children, Glasgow.

Our unit's validated protocol was used to determine whether CT scanning was required.[1] All CT scans were performed using the same standardised technique, as per our radiology department protocol.

All electronic records were reviewed; patients' demographics, radiology findings, management plans and outcomes were analysed. Data were recorded and analysed using Excel™ spreadsheet software and SPSS® statistical software. All data were stored on National Health Service password-protected computers throughout the study.

A picture archiving and communication system (Carestream, Rochester, New York, USA) was used to review images, using axial, coronal and sagittal reformatting. Two experienced otolaryngologists (RAC and HK) independently reviewed all imaging to grade each patient's peri-orbital disease (using the Chandler classification) and assess for sinonasal anatomical variants. This included specific assessment of presence and side of involvement for any septal deviation, concha bullosa, or evidence of breaches in the lamina papyracea. There were discrepancies in scoring for the presence of concha bullosa in two patients; the imaging scans for both patients were re-reviewed independently with consensus achieved on the second assessment. Children with evidence of pre-septal disease (Chandler score of 1) were excluded from further assessment in this study. Data were analysed using each patient's non-infected side as their own control.

TABLE I
CHANDLER SCORES FOR ALL CHILDREN WHO UNDERWENT ORBITAL COMPUTED TOMOGRAPHY

Chandler score	Patients (*n*)
1	18
2	5
3	22
4	3
5	0

Results

Forty-eight children underwent CT imaging during the study period. Those with pre-septal disease (Chandler score of 1, $n = 18$) were excluded; thus, 30 children were included in the study. The Chandler classifications for all children are shown in Table I.

The mean age for the included children was seven years (standard deviation = 3.9 years), with the range illustrated in Figure 1. The median length of admission was 4 days (range, 2 to 19 days). There was a slight male predominance (1.1:1).

We found a relatively similar distribution in terms of the side affected, with a small left-sided majority (1.3:1). The position of the septum and presence of concha bullosa are illustrated in Figure 2. In five children, we found possible evidence of ipsilateral breach in the lamina papyracea on CT.

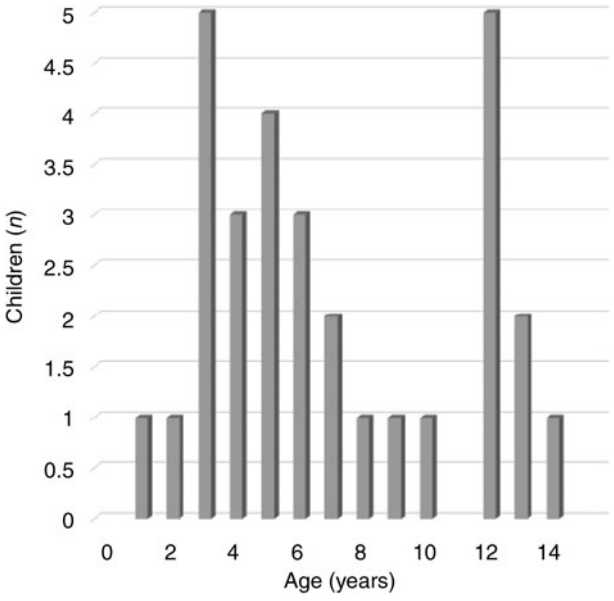

FIG. 1
Age distribution for children included in study.

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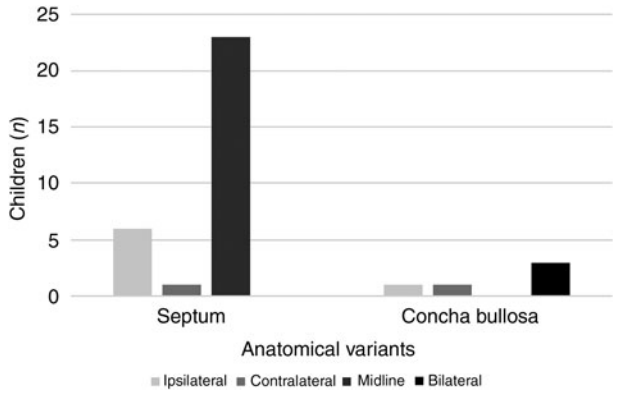

FIG. 2
Computed tomography evidence of anatomical variants.

Five children in the study group (17 per cent) had a concha bullosa (an example of which is illustrated in Figure 3); three cases were bilateral, one ipsilateral to the diseased orbit and one contralateral. Thus, there were four unilateral conchae and four contralateral, suggesting no obvious association between the presence of a concha bullosa and orbital infection (odds ratio = 1).

Seven children (23 per cent) had a deviated nasal septum (an example of which is illustrated in Figure 4), of which, six cases were ipsilateral to the involved orbit and one was contralateral. This difference was not statistically significant (McNemar's test with exact binomial, $p = 0.125$).

Discussion

This paper has addressed a topic which is currently extremely limited in terms of published information. However, the question of why one side is affected in orbital cellulitis cannot be explained by the bony or cartilaginous anatomical variants visible on CT scanning during the acute admission.

In our study, 83 per cent ($n = 25$) of the included children were taken to the operating theatre for drainage. This compares to only 30 per cent of the patients in the study by Grischkan *et al.*[10] It is unclear whether this indicates those authors had a much lower threshold for performing CT imaging of their children, or a much higher proportion of preseptal disease, orbital cellulitis or small subperiosteal abscesses, which ultimately did not require surgical management. The absence of the patients' Chandler classifications in their study does not allow us to compare our patient groups for these parameters. Unfortunately, we are also unable to compare our cohorts in terms of the general management of periorbital cellulitis, as the focus of the papers was on radiological findings in those who underwent imaging. Nevertheless, we have previously published that only 20 per cent of all children treated as in-patients with periorbital cellulitis required CT imaging using our protocol.[1]

When we compared overall findings, Grischkan *et al.*[10] had similar conclusions to our study. They also found no statistical correlation between incidence of septal deviation and presence of concha bullosa with the side affected. Their study did report a slightly higher incidence of septal deviation than our study (47 per cent compared to 23 per cent), but found similar rates of concha bullosa (13 per cent compared to 17 per cent). Certainly, the literature supports considerable variation in the incidence of septal deviation in the paediatric population, which ranges between 1 and 60 per cent, depending on geographical location and age of assessment.[12–16] Regarding the incidence of concha bullosa, again the literature has a fairly broad range of between 5 and 30 per cent.[17] Therefore, the incidence rates of septal deviation and concha bullosa

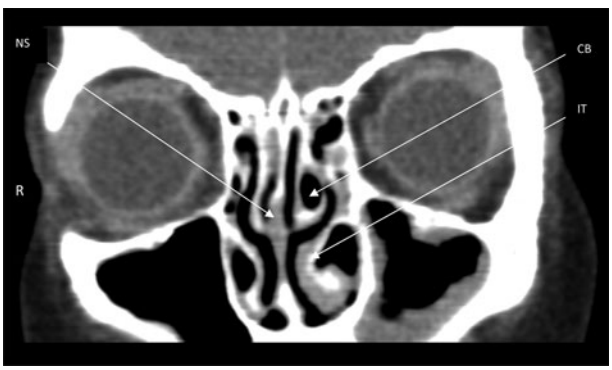

FIG. 3
Coronal computed tomography of the orbit, illustrating left concha bullosa of the middle turbinate. NS = nasal septum; CB = concha bullosa; IT = inferior turbinate; R = right

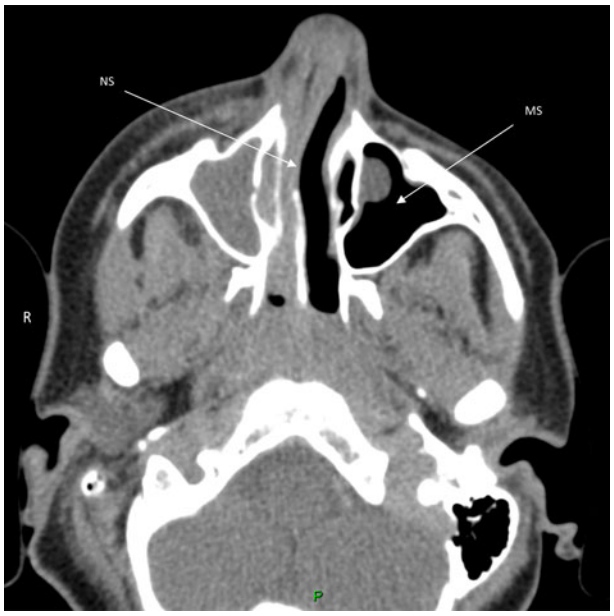

FIG. 4
Axial computed tomography of the orbit, illustrating right septal deviation. NS = nasal septum; MS = maxillary sinus; R = right; P = posterior

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in both of our cohorts appear to be in keeping with global rates.

In terms of our study's weaknesses, the small sample size may be a limiting factor. Other potential areas of bias concern the inclusion of only those patients who had CT imaging; thus, there may well have been patients with a Chandler score greater than 2, but who were managed without the need for a CT scan and were successfully treated. We also excluded patients found to have disease with a Chandler score of 1 from further evaluation. This was because a significant number of these children do not have a sinogenic origin of infection; thus, it was assumed that sinonasal anatomical variants would not be a significant factor in the side predilection. We felt that this could lead to potential bias against anatomical variants being identified as a cause.

We found the extremely low rates of recurrent disease in our patients remarkable, when either no surgical intervention or external drainage (which is our unit's 'gold standard' method) of orbital abscesses were performed. During these approaches, there are no alterations to any intranasal bony anatomical variants, and yet rates of recurrence or re-admission following treatment are exceptionally low, around 2.5 per cent in our previous study; none of these patients required any further imaging nor surgery.[1] This would strengthen the argument that both septal deviations and concha bullosa are not the significant factors in disease occurrence; one would have expected a high recurrence rate if these were the major contributory factors.

There may be subtle soft tissue features predisposing to sinusitis and osteomeatal complex obstruction, which may contribute more than the bony anomalies we studied. We only focused on bony anatomical variants in this study as we believe that assessment of soft tissue abnormalities in the paediatric population with acute rhinosinusitis does not enable differentiation between acute and chronic opacification. It is therefore not possible to know whether these changes are long-standing, thus contributing to the development of bacterial sinusitis through obstructing the osteomeatal complex or natural ostia, or purely an acute inflammatory reaction. This could only be addressed by repeating CT scanning following resolution of the orbital cellulitis, which would not be ethical, particularly in the paediatric population. Grischkan *et al.*[10] used the Lund–Mackay score as part of their assessment; however, this tool has only been validated for use in chronic rhinosinusitis, rather than in the acute setting. Nevertheless, they found a high degree of sinus opacification, regardless of whether surgical intervention or conservative management was adopted, which supports our avoidance of assessing soft tissue changes to determine causation.

- **This study investigated paediatric orbital cellulitis and its relationship to underlying sinonasal anatomy on computed tomography**
- **There were no correlations between any sinonasal bony or cartilaginous anatomical variants and orbital complications of acute rhinosinusitis**
- **The theory that these anatomical variants predispose to orbital cellulitis or associated complications in these children is not supported**
- **The findings suggest no advantage for any routine additional surgery at initial evacuation of the orbital abscess, except when required for surgical access**

Lastly, we did not include the integrity of the lamina papyracea as a major factor in our paper, as accurate assessment of this would be difficult during the acute infection. Furthermore, one cannot determine whether there was a pre-existing congenital dehiscence of the lamina papyracea, which could be blamed for causing the orbital abscess to develop, or whether the acute infection led to the dehiscence of the lamina papyracea. We already know that there are many proposed routes for sinonasal infections to spread to the orbit,[6] with the thin nature of the lamina papyracea already being established. In addition, contrary to septal deviations or concha bullosa, there are no well-established and validated procedures to deal with dehiscent lamina papyracea, therefore the presence becomes less clinically relevant.

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