Incidental findings of the nose and paranasal sinuses in orthodontic patients in the age of development: a retrospective study on CBCTs

F. Giaccaglia[1], G. Bruno[1], A. Gracco[2], A. De Stefani[1]

[1]DDS, Department of Neuroscience, School of Dentistry, University of Padua, Italy
[2]DDS, Ms, Associate Professor, Department of Neuroscience, School of Dentistry, University of Padua, Italy

e-mail: alberto.de.stefani@hotmail.it

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Abstract

Aim Nowadays, the use of CBCT in orthodontics and paediatric dentistry is constantly increasing. Since it allows a precise 3D visualisation of the entire head, CBCT can be used to identify alterations and pathologies of the jaws, but also of the sinonasal complex. Despite that, literature lacks studies focusing on the sinonasal complex of healthy orthodontic paediatric patients. Therefore, the aim of this cross-sectional retrospective study is to analyse the prevalence of incidental findings and anatomic variations of the nose and paranasal sinuses in orthodontic patients in the age of development.

Methods The 61 CBCTs that respected all inclusion criteria (patient's age under 15 years old and CBCT scans showing the entire sinonasal complex, data in DICOM format) were searched for: nasal septum deviation, Onodi cells, Haller cells, concha bullosa, sinus underdevelopment, sinus mucosal thickening, sinus cysts or polypoid formations. CBCTs were evaluated by two different orthodontists and their findings were then compared and statistically analysed.

Results The patients' median age was 11 years old. A high prevalence of anatomic variations and incidental findings was found, with the most frequent finding being nasal septum deviation, followed by thickening of the mucosa on the left side and on the right side of the maxillary sinus. No significant association between findings was found. The agreement level of the different analysis was very high.

Conclusion Considered the high prevalence of incidental findings, prescription of a CBCT to paediatric patiens seems crucial in order to to detect conditions that would require referral to a specialist.

KEYWORDS CBCT; Nose and Paranasal sinuses; Paediatric dentistry; Orthodontics.

Introduction

Since its introduction into dentistry in 1998, Cone Beam Computed Tomography (CBCT) has become widely used, for a variety of purposes. Its usage has gradually spread, from implantology and prosthetics, to orthodontics and paediatric dentistry.

Current diagnostic and treatment planning indications for CBCT use, both in orthodontics and paediatric dentistry, include impacted teeth, craniofacial anomalies (the most common being cleft lip and palate) and skeletal discrepancies requiring surgical intervention. Apart from these, there are many other cases in which CBCT is considered useful, such as localising supernumerary or unerupted teeth, planning boneborne orthodontic procedures, and evaluating upper airways morphology and alterations [Kapila and Nervina, 2015; Rosa et al., 2016; Ambu et al., 2017]. For these reasons, despite its ionizing radiations, a CBCT is frequently prescribed to orthodontic patients, most of whom are children and adolescents, in the age of development. [Abdelkarim, 2019]

CBCT, compared to orthopantomography and teleradiography, allows a precise 3D visualisation of the entire splanchnocranium, avoiding structural superimposition and image enlargement and distortion [Abdelkarim, 2019]. Therefore, it can be used to identify alterations and pathologies not only of the jaws, but also of the sinonasal complex [Nervina, 2012].

Although orthodontic literature is rich in studies evaluating the prevalence of incidental findings in the maxillofacial area of orthodontic patients, most of those studies focus on a single structure (usually the maxillary sinus) in a large population of adults [Pazera et al., 2011; Cha et al., 2007; Gracco et al., 2012; Raghav et al., 2014; Rossi et al., 2017], and there is no study on CBCTs focusing on the entire sinonasal complex in healthy paediatric patients [Glasier et al., 1986; von Kalle et al., 2012; Hill et al., 2004; Cotter et al., 1999; Tripodi et al., 2019; Maspero et al., 2019; Bruno et al., 2020].

The aim of this work is to study the prevalence of incidental findings and anatomic variations of the nose and paranasal sinuses in a population of orthodontic patients in the developmental age.

Methods

Two hundred CBCTs of patients of the dentistry department of Padua University's Hospital were considered for this study.

The work is a cross-sectional retrospective study and does not contain any studies with human participants or animals

FIG. 1 Coronal section of CBCT, showing a concha bullosa of the left middle turbinate (red arrow).

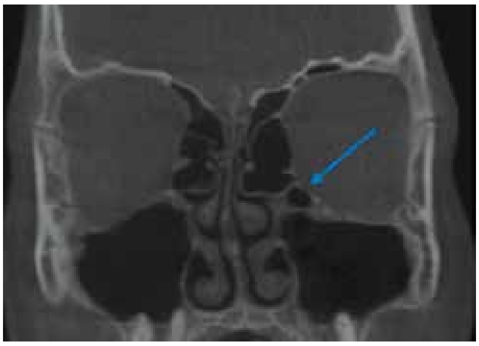

FIG. 2 Coronal section of CBCT, showing a left Haller cell (blue arrow).

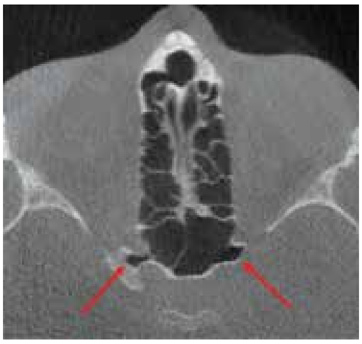

FIG. 3 Axial section of CBCT, showing bilateral Onodi cells (red arrows).

performed by any of the authors, neither Ethical approval by the local advisory board nor Informed consent by patients were necessary.

The following inclusion criteria had to be fulfilled: healthy patients in the developmental age (within 15 years of age), who had undergone a CBCT for orthodontic purposes; CBCT scans showing all paranasal sinuses and the entire nasal septum; data recorded in DICOM format. Moreover, these categories of subjects were excluded from the study: patients with systemic diseases or syndromes, patients with dental agenesis or supernumerary teeth, patients that underwent a previous orthodontic treatment.

Of the 200 CBCTs examined, only the 61 that respected all inclusion criteria were assessed for the presence of anatomic variations and incidental findings concerning the nose and paranasal sinuses.As anatomic variations were considered: nasal septum deviation, defined as "any deviation of the septal contour towards one side of the nasal cavity" [Cellina et al., 2020], paradoxical curvature of the middle turbinate, pneumatisation of turbinates (concha bullosa) and variations in the morphology of the ethmoid sinus, such as Haller cells and Onodi cells (Fig. 1–3). Incidental findings included: sinus mucosal thickening, defined as "any soft tissue density along a sinus wall, of more than 1 mm, that was not clearly polypoid in configuration" [Glasier et al., 1986]; presence of sinus cysts or polypoid formations; sinus underdevelopment, in relation to the age of the patient and the contralateral sinus (Fig. 4–7).

Mucosal thickening was furtherly categorised for the maxillary, the sphenoid and the frontal sinuses, into mild if less than 4 mm, severe if greater than 4mm, and total; while it was classified as partial or total for the ethmoid sinus [Glasier et al., 1986].

The CBCTs were examined twice by the first operator and a third time by a different operator.

All findings were then compared and statistically analysed, to determine the prevalence and 95% Confidence Interval (CI) of each variable. The authors also searched for an association between sinus mucosal thickening and presence of cysts or polypoid formations in the same sinus and between presence of concha bullosa and nasal septum deviation. The agreement of the three different analysis was then assessed, using Bangdiwala's B-statistic.

Results

The 61 CBCTs examined belonged to 32 males and 29 females, whose median age was 11 years (IQR 9–13 years), with the minimum age being 5 years old and the maximum age being 14 years old (Fig. 8).

Among the anatomic variations, the one most frequently observed was nasal septum deviation, seen in 49 patients, with a prevalence of 80%. Onodi cells were observed in 14 patients, with a prevalence of 23%, while Haller cells were found in 1 patient, with a prevalence of 2%. Concha bullosa of the middle turbinate was seen in 5 patients, with a prevalence of 5% on the right side and of 2% on the left side. One case of concha bullosa of the inferior turbinate was also observed, with a prevalence of 2% (Fig. 9). No paradoxical curvature of

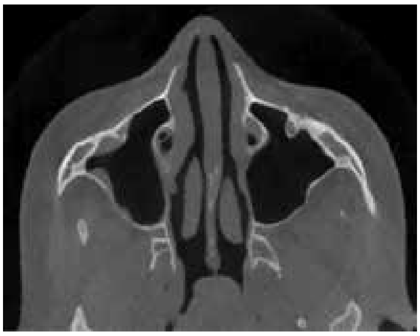

FIG. 4 Axial section of CBCT, showing sinus mucosal thickening in the right maxillary sinus.

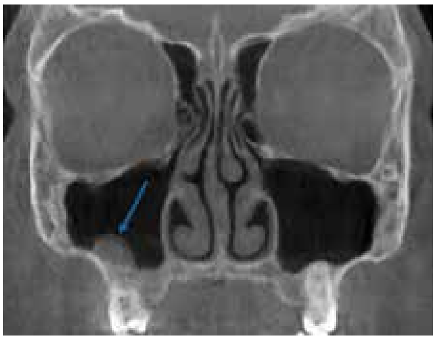

FIG. 5 Coronal section of CBCT, showing a cyst or polypoid formation in the right maxillary sinus (blue arrow).

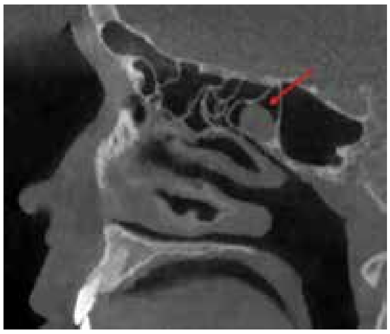

FIG. 6 Sagittal section of CBCT, showing a cyst or polypoid formation in the posterior ethmoid sinus (red arrow).

FIG. 7 Coronal section of CBCT, showing an underdevelopment of the right frontal sinus, compared to the contralateral part.

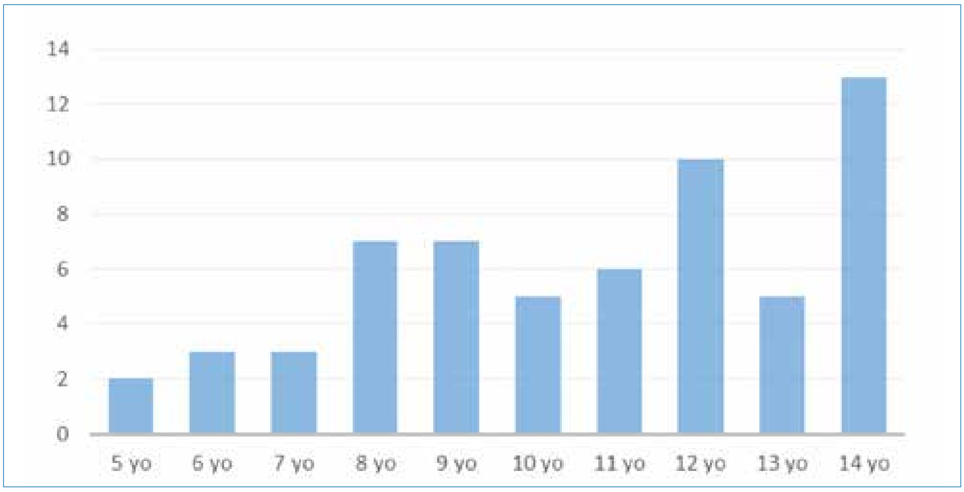

FIG. 8 Patients' age distribution.

the middle turbinate was observed. Prevalence, confidence intervals and agreement levels are reported in Table 1.

Mucosal thickening was most frequently observed in the maxillary sinus, with an overall prevalence of 71% on the left side and 61% on the right side. For the ethmoid sinus, a prevalence of 30% was found on the left side (18/61) and 23% on the right side (14/61). Mucosal thickening was also present, in 21 cases, in the sphenoid sinus, with an overall prevalence of 34%, and in the frontal sinus in 10 cases, with a prevalence of 16%. The exact distribution and classification of sinus mucosal thickening, together with the exact prevalence, confidence intervals and concordance values, can be seen in Table 2.

Underdevelopment of the frontal sinus was observed in 20 patients, with an overall prevalence of 33%, and in 11 cases it concerned just one half of the sinus, with a prevalence of 11% on the right side and 7% on the left side. As for other paranasal sinuses, the authors observed 2 cases of underdevelopment of the sphenoid sinus, with a prevalence of

	n/N	Prevalence (95% CI)	Intra-observer agreement (A1 vs. A2)	Inter-observer agreement (A1 vs. B)
Nasal Septum Deviation:			B=0.97	B=0.97
absent	12/61	20% (11 to 32%)		
present	49/61	80% (68 to 89%)		
Onodi Cells:			B=0.88	B=1
absent	47/61	77% (64 to 86%)		
present	14/61	23% (14 to 36%)		
Haller Cells:			B=1	B=1
none	60/61	98% (94 to 100%)		
right	0/61	0% (0 to 7%)		
left	1/61	2% (1 to 10%)		
Middle Turbinate Concha Bullosa:			B=0.99	B=0.99
none	56/61	92% (81 to 97%)		
right	3/61	5% (1 to 15%)		
left	2/61	3% (0 to 12%)		
Inferior Turbinate Concha Bullosa:			B=0.98	B=1
none	60/61	98% (94 to 100%)		
right	0/61	0% (0 to 7%)		
left	1/61	2% (1 to 10%)		
Middle Turbinate Paradoxical			B=0.98	B=1
Curvature:	61/61	100% (93 to 100%)		
none	0/61	0% (0 to 7%)		
right	0/61	0% (0 to 7%)		
left				

Prevalence, 95% confidence intervals (CI) and agreement levels of anatomic variations.

TABLE 1

	n/N	Prevalence (95% CI)	Intra-observer agreement (A1 vs. A2)	Inter-observer agreement (A1 vs. B)
Frontal sinus:			B=0.99	B=1
none	51/61	84% (71 to 91%)		
mild	2/61	3% (1 to 12%)		
severe	7/61	11% (5 to 23%)		
total	1/61	2% (1 to 10%)		
Sphenoid			B=0.97	B=1
sinus:	40/61	66% (52 to 77%)		
none	16/61	26% (16 to 39%)		
mild	5/61	8% (3 to 19%)		
severe	0/61	0% (0 to 7%)		
total				
right maxillary			B=0.98	B=0.99
sinus:	24/61	39% (27 to 53%)		
none	14/61	23% (14 to 36%)		
mild	23/61	38% (26 to 51%		
severe	0/61	0% (0 to 7%)		
total				
left maxillary			B=0.99	B=0.99
sinus:	18/61	29% (19 to 43%)		
none	22/61	36% (24 to 49%)		
mild	20/61	33% (22 to 46%)		
severe	1/61	2% (1 to 10%)		
total				
Right ethmoid			B=0.99	B=1
sinus:	47/61	77% (64 to 86%)		
none	14/61	23% (14 to 36%)		
partial	0/61	0% (0 to 7%)		
total				
Left ethmoid			B=0.99	B=1
sinus:	43/61	70% (57 to 81%)		
none	18/61	30% (19 to 43%)		
partial	0/61	0% (0 to 7%)		
total				

Distribution and classification of sinus mucosal thickening, together with exact prevalence, confidence intervals (CI) and concordance values.

TABLE 2

	n/N	Prevalence (95% CI)	Intra-observer agreement (A1 vs. A2)	Inter-observer agreement (A1 vs. B)
Frontal sinus: none right left bilateral	 41/61 7/61 4/61 9/61	 67% (54 to 78%) 11% (5 to 23%) 7% (2 to 17%) 15% (7 to 27%)	0.98	0.99
Ethmoid sinus: none right left bilateral	 60/61 0/61 0/61 1/61	 98% (94 to 100%) 0% (0 to 7%) 0% (0 to 7%) 2% (1 to 10%)	B=1	B=1
Sphenoid sinus: none right left bilateral	 59/61 0/61 0/61 2/61	 97% (88 to 99%) 0% (0 to 7%) 0% (0 to 7%) 3% (0 to 12%)	B=1	B=1
Maxillary sinus: none right left bilateral	 60/61 0/61 0/61 1/61	 98% (94 to 100%) 0% (0 to 7%) 0% (0 to 7%) 2% (1 to 10%)	B=1	B=1

Prevalence, 95% confidence intervals (CI) and agreement levels of sinus underdevelopment

TABLE 3

	n/N	Prevalence (95% CI)	Intra-observer agreement (A1 vs. A2)	Inter-observer agreement (A1 vs. B)
Maxillary sinus: none right left bilateral	 50/61 4/61 4/61 3/61	 82% (67 to 90%) 7% (2 to 17%) 7% (2 to 17%) 4% (1 to 15%)	B=1	B=1
Ethmoid sinus: none right left bilateral	 59/61 2/61 0/61 0/61	 97% (88 to 99%) 3% (0 to 12%) 0% (0 to 7%) 0% (0 to 7%)	B=1	B=1

Prevalence, 95% confidence intervals (CI) and agreement levels of sinus cysts or polypoid formations

TABLE 4

3%, 1 case of underdevelopment of the ethmoid sinus, with a prevalence of 2%, and 1 case of bilateral underdevelopment of the maxillary sinuses, with a prevalence of 2% (Table 3). Among those, one patient showed underdevelopment of all paranasal sinuses (Fig. 10).

The presence of cysts or polypoid formations was observed in 2 cases in the right ethmoid sinus, with a prevalence of 3%, and in 11 cases in the maxillary sinus, with an overall prevalence of 18%: it was bilateral in 3 cases, with a prevalence of 4%, while unilateral in 8 cases, with a prevalence of 7% on the right side (4/61) and of 7% on the left side (4/61) (Table 4).

The association between presence of concha bullosa of the middle turbinate and nasal septum deviation is non statistically significant (p=0.99), as well as the one between mucosal thickening and presence of cysts or polypoid formations in the maxillary sinus (p=0.11), and in the ethmoid sinus (p=0.65). All findings showed a high level of intra-observer agreement, with B ranging from 0.88 to 1, and an excellent level of inter-observer agreement, with B ranging from 0.97 to 1 (Tables 1–4). Only 3 patients showed no anatomic variations nor other findings.

FIG. 9 A rare case of concha bullosa of the inferior turbinate in a 12-year-old female patient, in coronal and axial projection (red arrows).

Discussion

The prevalence of nasal septum deviation reported in literature widely varies, in the adult population, based on diagnostic criteria and procedures, from 14% to 90% [Cellina et al., 2020; Gray, 1978]. The prevalence of 80% that was found, seems consistent with that interval, although there is a lack of studies assessing the prevalence of nasal septum deviation in paediatric patients using CBCTs.

The highest prevalence of Onodi cells reported in literature is 8–14% [Kantarci et al., 2004], while a prevalence of 23% was found in this study. As for Haller cells, the prevalence most often reported in literature is 10–18% [Kantarci et al., 2004], whereas a prevalence of 2% was observed in this study. This discrepancy might be due to the fact that authors considered a paediatric population, in which the paranasal sinuses are still developing; therefore, Haller cells may develop later for expansion of the ethmoid sinus, that might instead mimic Onodi cells, while extending posteriorly.

The same goes for concha bullosa of the middle turbinate,

FIG. 10 A case of generalised opacification and underdevelopment of paranasal sinuses. Coronal and axial projections and 3D frontal reconstruction.

that has a reported prevalence of 14–53% [Stallman et al., 2004] in the adult population, while an overall prevalence of 7% was found in this study (5% on the right side and 2% on the left side).

The authors reckon that the absence of findings of paradoxical curvature of the middle turbinate could be explained by the same reason, which is the uncompleted growth, in paediatric patients, of nasal and paranasal structures.

The prevalence of sinus mucosal thickening, as well as the prevalence of sinus cysts or polypoid formations, appears consistent with the ones reported in previous similar studies [Glasier et al., 1986; Cotter et al., 1999; Tatli et al., 2001; Diament et al., 1987].

Among anatomic variations, the agger nasi cells were not considered, since their prevalence widely varies in literature, from 10% to 89% [Kantarci et al., 2004], and some authors do not consider them as anatomical variants but just as the most anterior group of ethmoid cells.

Evaluation of sinuses underdevelopment was not easy, since literature lacks recognised diagnostic criteria, especially for paediatric patients, whose paranasal sinus growth is not yet completed. Therefore, the authors reported as underdeveloped all those cases that showed one half of a sinus considerably smaller than the other or whose sinus(es) appeared underdeveloped compared to patients of the same age.

Two interesting cases of uncommon conditions were found.

The first one was a 12 year-old male patient, that presented hypoplasia, together with total or subtotal opacification, of all paranasal sinuses, but was completely asymptomatic. Literature reports the case of an adult female patient showing a similar situation [Güven et al., 2010] (Fig. 10).

The second one was a 12 year-old female patient with a concha bullosa of the inferior turbinate, which is a rare finding, with a prevalence, in literature, lower than 1% [Cellina et al., 2020; Pittore et al., 2011] (Fig. 9).

As for the lack of statistical significance of the association between concha bullosa of the middle turbinate and nasal septum deviation and between sinus mucosal thickening and presence of cysts or polypoid formations in the same sinus, it is most likely due to the low numerousness of the cohort, since these associations are extensively reported in literature [Glasier et al., 1986; Stallman et al., 2004].

Since the levels of intra- and inter-observer agreement are really high, the method used by the authors to evaluate CBCTs can be considered effective and repeatable, as long as observers are adequately trained.

Conclusions

Considered the high prevalence of incidental findings of the nose and paranasal sinuses, it is crucial for orthodontists to be able to accurately analyse the CBCT of paediatric patients in order to detect all those conditions that require referral to a specialist.

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Declaration of interest statement

No conflict of interest has been declared by the authors.

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