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The prevalence and significance of incidental paranasal sinus abnormalities on MRI*

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SUMMARY

Morphological changes in the paranasal sinuses are regularly noted on MRI, but little is known about the incidence and significance of these changes in the general population. The purpose of this study was 1) to classify the morphological changes in the paranasal sinuses seen on MRI 2) to investigate the prevalence, site and type of paranasal abnormalities and 3) to evaluate the significance of the findings by relating them to the presence of sinusitis symptoms, allergy, smoking habits and seasonal variations. In a one-year period, 404 patients referred to MRI for suspected intracranial neurological pathology were prospectively investigated. Before undergoing the scan the patients completed a questionnaire. The observed morphological conditions were classified so that mucous thickening <5 mm was recorded as normal; ≥5 mm, total sinus opacification or fluid and polyps as pathological. According to this classification 31.7% of the patients had pathological findings in the sinuses. A significantly higher incidence was found in the winter period and in patients with symptoms associated to sinusitis. "Blocked nose" was the only symptom occurring significantly more often in patients with pathological changes. There was no significant relationship between paranasal sinus abnormalities and sex, age, allergy, smoking habits, previous events of sinusitis or frequent events of colds. Criteria for pathological MRI findings in the paranasal sinuses are desirable and might improve the basis for a decision on the correct medical or surgical treatment.

Keywords: abnormality, classification, MRI, paranasal sinus, significance

INTRODUCTION

Acute sinusitis is a common clinical problem in general practice as well as in departments of otorhinolaryngology and the diagnosis is often based on symptoms and clinical examinations alone (Lindbæk and Hjortdahl, 1993). If plain radiographs, computed tomography (CT) or magnetic resonance imaging (MRI) are performed, a clear definition of normal or abnormal conditions of the paranasal sinuses is lacking. In the present study we have chosen MRI as the diagnostic imaging technique due to the great sensitivity of this technique in determining the extent of soft tissue components and its multiplanar capability (Mahmood F. Mafee, 1994).

In our experience morphological changes in the paranasal sinuses are regularly noted on MRI in patients referred for neuroradiological assessment, but little is known about the real incidence and significance of these morphological changes in the general population.

The purpose of this study was 1) to classify the morphological changes in the paranasal sinuses seen on MRI 2) to investigate the prevalence, site and type of paranasal abnormalities and 3) to evaluate the significance of the findings by relating them to the presence of sinusitis symptoms, allergy, smoking habits and seasonal variations.

MATERIALS AND METHODS

This prospective study was performed at the Centre for Nuclear Magnetic Resonance, Skejby Sygehus, Aarhus University Hospital, Denmark. The criteria for inclusion were: patients had to be 18 years or older and referred for MRI due to suspected intracranial neurological pathology. Patients referred on suspicion

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of sinusitis or other intracranial infections were excluded. Also patients with known HIV-seropositivity were excluded because of the suspected higher prevalence of paranasal sinus abnormalities in this group of patients (Chong et al., 1993). A total of 443 patients fulfilled the inclusion criteria but 18 did not want to participate and 21 were not scanned due to lack of compliance and claustrophobia. The inclusion of the 404 evaluable patients was equally distributed over one year from the first of May 1996 to the 30th of April 1997. The inclusion procedure was that the patients received written and verbal information about the project and were asked to fill in a questionnaire before undergoing the scan. The questionnaire was commenting on age, sex and the presence or absence of (1) allergy; in case of an affirmative answer, allergen(s) and way of manifestation (hay fever, asthma, rash or something else), (2) current symptoms of fever, blocked nose, runny nose, headache, tenderness/pain over the sinuses, tenderness/painful teeth, cough; in case of an affirmative answer, the duration of the symptom(s) (3) previous events of sinusitis; in case of an affirmative answer, the number of times and time of the last event, (4) cold more than twice annually, (5) smoking habits; in case of an affirmative answer, the consumption of tobacco.

On the basis of the presence / absence of one or more of the sinusitis associated symptoms the patients were divided into a symptomatic and an asymptomatic population.

The scans were performed on a 1.5 Tesla magnet. All T_2-weighted images were performed in the standard axial plane. If sagittal or coronal images were performed, they were examined too. All the MRI examinations were reviewed by the same radiologist who was blinded with regard to the questionnaires' results. Eight anatomic areas (4 on each side) were examined separately: frontal, maxillary, sphenoid and ethmoid. The three first mentioned paranasal sinuses were classified as shown in Table 1. Due to the normal physiological cyclical changes that occurs in the ethmoids (Zinreich et al., 1988) a special classification was made for this sinus group (Table 2). If one sinus showed more than one abnormality or variation in the degree of mucosal swelling at different regions of the sinus concerned, only the most pronounced abnormality or swelling was recorded.

Statistical analysis

SPSS package for personal computers. The tests used are the chi-square test and one-way analyses of variation. Level of significance is 5%.

RESULTS

Of the 404 patients, 166 were men and 238 women with a mean age of 44 years (range 18-79). Through the study period a mean of 33,7 patients (range 28-42) were included every month corresponding to a mean of 101 patients (range 99-102) in every of the four seasons (Figure 1). In accordance with the criteria of classification (Table 1 and 2), 128 cases (31.7%) of the 404 images showed abnormalities > grade 1 in one or more of the 8 paranasal sinuses (Table 3). When the left and right sinuses were considered together, abnormalities were most commonly seen in the maxillary sinuses (33.7%) followed by the sphenoid (4.2%),

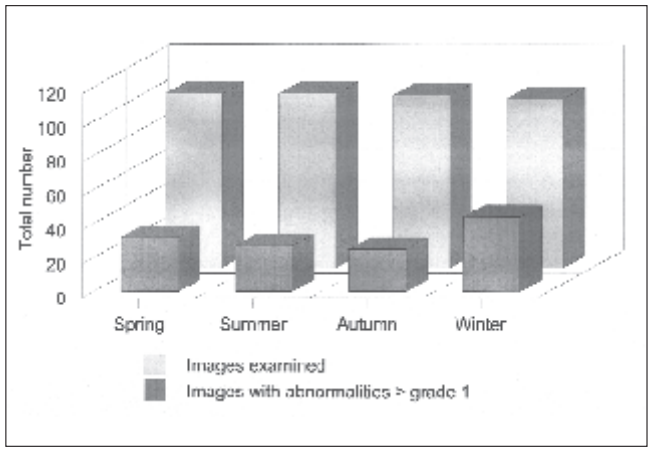

Figure 1. The distribution of images on the 4 seasons.

Table 1. Classification of MRI signals in the frontal, maxillary and sphenoid sinuses.

Grade	Definition
0	Absence of signal: normal
1	Visible illumination of the sinus mucosa however < 5 mm: normal
2	Thickening of the mucosa membrane ≥5 mm however < 10 mm: pathological
3	Thickening of the mucosa membrane ≥10 mm: pathological
4	Total sinus opacification or fluid level: pathological
5	Polyp or retention cyst: pathological
6	Other: abnormalities due to previous surgery, hypo- or aplasia: pathological

Table 2. Classification of MRI signals in the ethmoids.

0	Absence of signal: normal
1	Minimal or moderate sinus opacification: normal
4	Marked or total sinus opacification: pathological

Table 3. The number of cases with one or more sinuses affected out of 404 evaluable patients.

Number of sinuses affected	Number of cases	Percent
0*	276	68.3
1	88	21.8
2	26	6.4
3	6	1.5
4	5	1.2
5	2	0.5
6	1	0.2
Total	**128**	**31.7%**

* Cases with normal MRI s e.i. grade ≤1

Table 4. The prevalence of uni- and bilateral normal and pathological morphology.

Grade	FronR*	FronL	FronB[1]	MaxR	MaxL	MaxB[1]	SphenR	SphenL	SphenB[1]	EthmoR	EthmoL	EthmoB[1]
0	17	14	356	34	16	270	7	6	374	10	10	300
1	13	15	12	15	35	34	5	7	7	12	8	73
2	0	2	2	11	14	6	0	3	3			
3	0	0	0	7	3	3	0	0	0			
4	0	0	2	11	11	10	5	1	3	0	4	9
5	1	1	0	25	26	5	1	1	0	0	0	0
6	1	0	1	2	1	1	0	0	0	0	0	0
Total[2]	**2**	**3**	**5**	**56**	**55**	**25**	**6**	**5**	**6**	**0**	**4**	**9**

[1] The number of patients with the current graduation present bilaterally.
[2] Total number of radiological abnormalities ~ grade >1.
* Fron-, Max-, Sphen-, Ethmo-, R and L are abbreviations of frontal, maxillary, sphenoid, ethmoid, right and left, respectively. Cases recorded under -R or -L represent the number of cases with unilateral affection.

the ethmoid (3.2%) and the frontal sinuses (2.7%) (Table 4). No significant left-right variations were observed. In 42/128 (32.8%) of the cases, the abnormality was classified as grade 4 corresponding to 10.4% of the 404 images showing morphological changes compatible with the definition of acute sinusitis (Lindbæk et al., 1996). If the cases in which grade 5 (mucosal polyps or retentioncysts) was the only abnormality described, were excluded, the number of abnormal cases was reduced from 128 (31.7%) to 79 cases (19.6%). Mucosal polyps or retentioncysts were seen in 60 cases (14.9%). These were localized in the sinus groups as shown in Table 4. In 52 of the cases the polyps were the only pathological finding in the sinus concerned. Aplasia (grade 6) was seen in 5 cases (1.2%), 2 cases in the frontal sinuses and 3 cases in the maxillary sinuses. In one maxillary sinus sequelae after operation were seen.

We found a positive correlation between the season of scan and the incidence of abnormalities. In the winter period significantly more of the examined images 44.4% (44/99) showed changes > grade 1 ($\chi^2 = 10.975$, df = 3, $p < 0.012$) than in the other 3 seasons. This difference was primarily caused by a high frequency of grade 4 (acute sinusitis) as 19 of the 44 images with abnormalities were classified like that. The incidence of grade 4 was statistical significantly higher in the winter ($\chi^2 = 11{,}388$, df = 3, $p < 0.010$). In spring grade 4 made up the lowest percentage of the morphological changes with only 18.8% as grade 2 made up the majority of changes (40.6%) at the season concerned. Abnormalities were apparent on the MRΓs of 35.5% of men compared with 29.0% of women, but the difference was not significant as well as there was no age dependency.

All the patients completed the questionnaire. One hundred thirty of the patients (32.2%) stated to suffer from allergy. The allergen most often mentioned, in 37 cases, was different kinds of drugs (sulphonamides, acetylsalicylic acid, etc.), 34 patients stated to have allergy but did not know the allergen, 23 patients were allergic to more than one allergen, 18 to grasses and plants, 13 to nickel and 3 and 2 patients were allergic to animal and dust, respectively. Among the 130 patients with allergy, 63 had hay fever, 27 asthma, 59 rash and in 17 patients the allergy manifestated in another way. As it shows up, some of the patients had more than one kind of manifestation. One hundred and fifty-three of the patients (37.9%) had one or more symptoms at the time of MRI scan (Table 5). In 46 of the 153 patients (30%) the symptoms had been present for less than 4 weeks, 54 (35.3%) had had symptoms for more than 4 weeks, 40 patients (26%) characterized the symptoms as chronically present and 11 patients (7.2%) did not answer the question of symptom duration. At the question concerning previous events of sinusitis 221 patients (54.7%) denied ever to have had sinusitis, 179 patients (44.3%) stated to have had sinusitis previously and 4 did not answer. Among the 179 patients, 161 stated to have had sinusitis between 1 and 20 times (median 7,5 times), 3 described the sinusitis as chronically present and in 15 cases the question was unanswered. Forty-eight patients had had the last event of sinusitis within the last year but neither patient thought to have sinusitis at the time of MRI scan. Concerning the question having a cold more than twice annually, 106 patients suggested that it was the case. Two hundred and twenty-two patients were non-smokers (55%) (145 had never smoked), 176 were smokers and in 6 cases the question was unanswered. The consumption of tobacco among the 176 smokers was as follows: 65 smoked 1-10 g/day, 88 smoked 11-20 g/day, 18 smoked 21-40g/day and for

Table 5. The number of patients with symptoms.

Number of patients = 153	
Fever	9
Blocked nose	56
Runny nose	48
Headache	77
Tenderness/pain over the sinuses	28
Tenderness/painful teeth	39
Cough	40

the last 8 patients the tobacco consumption was unknown. Abnormal paranasal sinuses were present significantly more frequent in the symptomatic population with 38.5% than in the asymptomatic group with 27.5% ($\chi^2 = 5.384$, df = 1, $p < 0.02$). The difference was found only if more than one sinus was affected. "Blocked nose" was the only symptom which was significantly more frequently present among patients with pathological changes than in patients with normal MRI ($\chi^2 = 6.531$ df = 1, $p<0.011$). If the patient had morphological changes compatible with acute sinusitis (grade 4) in one or more sinus, 59.5% of the patients had symptoms. In this patient group the following symptoms, headache, cough, runny nose, blocked nose and tenderness / painful teeth, were significantly more frequently present than in the other patients (χ^2 ~ 6.982 - 3.885, df = 1, p< (0.008-0.049). We did not find any difference in the duration of symptoms between the group with and without morphological changes and there was no correlation between previous sinusitis, the time of the last event of sinusitis, suffering from cold more than twice annually and the actual abnormality seen. There was no association between suffering from allergy, irrespective of the form of manifestation (asthma, hay fever, etc.) or the allergen and the frequency and nature of the abnormalities observed. Nor was there any significant difference between smokers, irrespective of the tobacco consumption, non-smokers and the presence of abnormality.

In the 60 cases with polyps / retentioncysts we did not find any relation to sex, age, season, allergy, symptoms, previous sinusitis, frequent events of cold or smoking habits.

DISCUSSION

Going through the literature the percentage of patients with incidental radiologic abnormal paranasal sinuses varies between 24.7% and 59% (Moser et al., 1991; Gordts et al., 1996). We found abnormalities in 31.7% of the cases. This correlates relatively well with the studies of Moser et al., (1991) and Cooke and Hadley (1991) who found 24.7% and 37.5%, respectively, but less well with studies like Havas et al., (1988) with 42.5%, Patel et al., (1996) with 49.2%, Jones et al., (1997) with 53% and Gordts et al., (1996) with 59%. The discrepancies may partly be explained by the use of different diagnostic techniques, computed tomography (CT) or MRI, but we think that the most important explanation is the different ways of classification of the morphological changes observed or in other words, the lack of a clear and unambiguous definition of normal and abnormal morphology in the paranasal sinuses. The topic of debate is primarily the thickness of the mucosa. In some studies the images are classified as abnormal due to "mucosal thickening" (Moser et al., 1991; Havas et al., 1988) or "minimal mucosal thickening" (Cooke and Hadley, 1991; Jones et al., 1997). In other studies the authors have chosen a cut-off value of >2 mm (Patel et al., 1996), >3 mm (Gordts et al., 1996) ≥4 mm in asymptomatic patients (Rak et al., 1991), ≥5 mm (Lindbæk et al., 1996) and >6 mm (Katz et al., 1995). In the present study we have chosen a cut-off value of ≥ 5 mm in the frontal, maxillary and sphenoid sinuses. By choosing this relatively high cut-off value we believe, that we have overcome the problem of over-diagnosing due to the high sensitivity of MRI (Antila et al., 1993) and at the same time have excluded cases with slight thickening due to a common cold (Gwaltney et al., 1994). In the ethmoids we have chosen another (Table 2) but previously used classification (Lindbæk et al., 1996) partly due to the small size of the ethmoid cells, partly due to the nasal cyclical changes (Zinreich et al., 1988; Kennedy et al., 1988).

Another topic of debate is the pathogenecity of polyps or cysts. Gordts et al., (1997) recorded the presence of isolated maxillary polyps or cysts in adults as non-pathological as it is not linked with a higher prevalence of pathological signals at the level of the other sinuses. This point of view is not in accordance with other studies. Laine and Smoker (1992) stated that polyps result from persistent membrane hyperplasia often associated to allergy; Havas et al., (1988) found relationship between polyps and previous events of sinusitis; Ziefer (1993) stated that polyps were associated with allergic rhinitis and chronic inflammatory disease and that individual polyps can obstruct the drainage ostia of the sinuses predisposing to recurrent sinus infection. We have classified the polyps and retentioncysts as pathological findings in light of the above mentioned arguments although we neither found any correlation to allergy or previous events of sinusitis nor to symptoms like Rak et al., (1991).

In accordance with Jones et al., (1997) we find the maxillary sinus group most commonly affected but not followed by the ethmoids but by the sphenoids, the ethmoids and finally the frontal sinuses. Other studies find affection of the ethmoids more often than the maxillary sinuses (Patel et al., 1996; Havas et al., 1988). That we find the ethmoids so rarely affected is due to the higher cut-off value. If we in the present study had classified the cases with minimal changes, corresponding to grade 1, as pathological, the maxillary sinuses would still be the most commonly affected but followed by the ethmoids. As Gordts et al., (1996) we do not observe any left-right variation. Polyps and retentioncysts are observed in 14.9% of the cases. This number is in accordance with previous studies 12.5% and 21%, respectively (Moser et al., 1991; Gordts et al., 1996). In 49 cases polyps and retentioncysts are the only abnormality seen. This observation may support the view of Gordts et al., (1997) due to the lack of affection of the other sinuses, but we do not find that this is an argument of a classification as non-pathological. The number of cases with aplasia corresponds to the findings by Pollei and Harnsberger (1989).

More men are seen in the group with abnormalities but the difference between the two sex is not statistical significant. This is in accordance with the findings by Cooke and Hadley (1991) while Havas et al., (1988) found a male predominance. Corresponding to results from studies of Cooke and Hadley (1991) and Havas et al., (1988) age, smoking habits, irrespective of tobacco consumption and allergy do not correlate with the MRI findings. Concerning age dependency, the prevalence of pathological signals in children may be higher than in adults. Gordts et al., (1997) demonstrated a relatively high prevalence of pathological signals in children with a progressive decrease in the overall prevalence with age: <2 years: 54%; 2-7 years: 45%; >7 years: 40%. Other studies with children have shown prevalences

in the same magnitude, 41% to 47%, respectively (Lesserson et al., 1994; Manning et al., 1996). Contrary to other studies (Cooke and Hadley, 1991; Havas et al., 1988), we do find a positive correlation between the season of scan and the incidence of morphological changes with statistical significantly more pathological changes in the winter period. As the difference primarily is caused by "grade 4-cases", this variation is expected due to more infections in the cold and wet season. In the case of Havas et al., (1988) the lack of seasonal variation may be explained by the warmer Australian climate and in the study of Cooke et al., (1991) which originate from a climate very much like the Danish, the explanation may be their relatively short inclusion period of the prospective population (between January and May) but unknown for the retrospective group. These above mentioned circumstances may also explain the relatively low number found by Moser et al., (1991) as the season of scan does not appear in the retrospective design. In our study grade 2 makes up 40.6% of the abnormalities found in spring. As the number of pollen is high in the spring our hypothesis is that grade 2 may represent the morphological changes seen in patients with allergy to pollen although we, like Havas et al., (1988), have not found any significant correlation between suffering from allergy and any special nature of abnormality like pansinusitis or polyps (Zeifer, 1991; Laine and Smoker, 1992).

Cooke et al., (1991) suspect that slight mucosal thickening, especially in the ethmoids, may represent the legacy of an earlier acute upper respiratory tract infection or may act as a source of chronic infection, intermittently leading to symptomatic sinus disease. We cannot confirm these suspicions as we have not found any correlation between suffering from frequent events of cold, previous events of sinusitis and the actual abnormality, irrespective if the abnormality is defined equal to or greater than grade 1.

The symptoms of sinusitis are often unspecific and may not reflect the true state of the paranasal sinuses. As it appears from the present study, symptoms as fever and "tenderness/pain over the sinuses" are not seen significantly more often in patients with morphological changes than in patients with "clean" sinuses. However, we have allowed ourselves to categorize the patients as symptomatic and asymptomatic on the basis of these rather unspecific symptoms as they make the patients seek medical assistance or make the physician suspect sinusitis. Pathological changes are present significantly more frequent in the symptomatic group than in the asymptomatic. We believe that our group of patients is reasonably representative of the general population concerning the actual problem as patients which may have a higher prevalence of sinus abnormalities such as patients suspected of intracranial infections or patients with known HIV-seropositivity are excluded (Chong et al., 1993; Armstrong et al., 1993). As the included patients are referred on suspicion of intracranial neurological pathology there may be a higher prevalence of complaints of headache than in a quite normal population, but as "blocked nose" and not headache, is found to be the most specific symptom for the presence of morphological changes on the MRI, we do not think this has biased our results.

In conclusion, according to our classification of morphological changes in the paranasal sinuses 31.7% of the patients had pathological findings on MRI. A significantly higher incidence was found in the winter period and in patients with symptoms associated to sinusitis. "Blocked nose" was the only symptom occurring significantly more often in patients with pathological changes. There was no significant relationship between paranasal sinus abnormalities and sex, age, allergy, smoking habits, previous events of sinusitis or frequent events of colds. Criteria for pathological MRI findings in the paranasal sinuses are desirable and might improve the basis for a decision on the correct medical or surgical treatment.

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