

Study on the reproducibility of the Waters' views of the maxillary sinuses*

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SUMMARY

Objective: This study intended to investigate the reproducibility of the Waters' view for maxillary sinusitis and to define its place in clinical practice.

Materials and method: Radiographs of 80 maxillary sinuses of patients with suspected acute sinusitis were read by 6 radiologists, 6 ENT surgeons, 6 general practitioners (GPs). Interobserver agreement was calculated using the kappa statistic.

Results: Agreement was good ($\kappa = 0.63$; 95%CI 0.58-0.68) between radiologists when the criteria used to define acute sinusitis were "important mucosal swelling, air-fluid level or complete opacity". When the criteria "air-fluid level or complete opacity" were used, agreement was fair ($\kappa 0.39$; 95%CI 0.35-0.44). Between ENT-surgeons kappas were respectively 0.58 (95%CI 0.53-0.63) and 0.37 (95%CI 0.32-0.42). Between GPs kappas were respectively 0.30 (95%CI 0.25-0.35) and 0.28 (95%CI 0.23-0.33).

Conclusion: The reproducibility of Waters' views of the maxillary sinuses is best when the interpretation is performed by radiologists or ENT surgeons, and when criteria for sinusitis are: important mucosal swelling, air fluid level or complete opacity. The good interobserver agreement combined with the known high negative predictive value of these diagnostic criteria makes the Waters' view only useful for ruling out acute sinusitis.

Key words: maxillary sinusitis, upper respiratory tract infection, sinus radiology, Waters' view, and interobserver agreement.

INTRODUCTION

Practice guidelines on acute sinusitis no longer recommend plain radiographs of the sinuses for confirming the diagnosis but advise to treat patients with the clinical picture of acute sinusitis without any further imaging of the sinuses [1, 2, 3, 4]. However, in daily practice clinical pictures are seldom clear-cut. Frequently complaints are vague, ill defined and pointing in many possible directions [5] of which sinusitis might just be one. Diagnostic tests are often intended to rule out and limit the number of possibilities rather than to confirm a suspected diagnosis. The most suitable test for ruling out a disease is a test with a high sensitivity since in this case a negative result is unlikely to be falsely negative [6]. Conventional radiography of the maxillary sinuses has a high sensitivity to detect fluid in the maxillary sinuses: a meta-analyse of six diagnostic trials, all comparing results of plain sinus radiographs with results of puncture of the

maxillary sinuses, concludes that sensitivity is 0.90 when mucosal thickening, fluid level or total opacity are used as diagnostic criteria for acute sinusitis [7]. In patients with ambiguous complaints this investigation could thus be a simple mean rule out sinusitis, but only on condition that it is also reproducible, that interpretations of the same test result by different observers or on different times sufficiently agree. Reproducibility of sinus radiographs is until now only limitedly investigated in four studies [8, 9, 10, 11]. Two concerned radiographs of patients with suspected acute sinusitis [9, 11], which respectively compared interpretations by three radiologists of 95 radiographs and interpretations by a radiologist and an ENT-surgeon of 50 radiographs.

In the present study it was our intention to explore more thoroughly the reproducibility of the Waters' view of the maxillary sinuses in patients with suspected acute sinusitis. For this end we compared readings of a larger number of observers, used

different sets of diagnostic criteria and included as observers not only ENT-surgeons (ENTs) and radiologists, but also general practitioners (GPs) because GPs make for the greater part the decisions about the management of uncomplicated acute sinusitis in primary care.

In this way we wanted to answer the question whether or not plain radiographs of the maxillary sinuses have – besides a high sensitivity – also a sufficient reproducibility to be efficacious in clinical practice to rule out acute maxillary sinusitis.

METHODS

Population

In 1999 a randomised controlled clinical trial was performed investigating the effectiveness of antibiotics in primary care patients with suspected sinusitis [12]. In this study a Waters' view of the maxillary sinuses was performed in 292 patients. These radiographs were taken in different radiological units and collected and evaluated centrally. For the present study – which took place in 2002 – a random sample of 40 was taken from these 292 radiographs.

Study design

These 40 radiographs, showing 80 maxillary sinuses, were interpreted by six radiologists, six ENTs and six general practitioners. The 18 doctors had different degrees of experience and worked in different settings. The doctors were asked to classify their findings in one of following six categories: normal, slight mucosal swelling, important mucosal swelling, air-fluid level, total opacity, interpretation not possible. "Important mucosal swelling" meant that the mucosal thickening was considered sufficiently pathological to lead to further (diagnostic or therapeutic) action.

The reports were recorded by one researcher (RS) attending all 18 reading sessions using standardised forms with tick boxes. Doctors did not receive clinical information on the patients. The ethics committee of the Ghent University Hospital approved the study.

Analysis

Results were first checked for eccentric performers. The data were then classified in three ways. First we looked at the agreement between doctors of the same discipline when classifying the radiographs in the 6 categories (= classification 1). Subsequently, the 6 categories were rearranged into three: normal, sinusitis and interpretation impossible. For distinguishing normal/sinusitis we used two different cut-off points: in "classification 2" we defined "sinusitis" as important mucosal swelling or air-fluid level or total opacity. In "classification 3" we defined "sinusitis" as air-fluid level or total opacity

To assess interobserver agreement within each physician group we started by calculating the proportion of radiographs for which all six agreed and for which the majority (4 out of 6) agreed. These simple measures of agreement may, however, exaggerate the true level of concordance, especially when almost all or very few of the radiographs are abnormal – as is

the case in classification 3. Therefore correction for chance agreement is necessary. This was done by calculating the kappa statistic for multiple observers [13, 14], a statistical method to measure agreement between different observers, which takes into account chance agreement. The range for kappa is -1 to +1: -1 indicates perfect disagreement, +1 indicates perfect agreement, 0 means agreement equals chance agreement, values between 0-0.2 present poor agreement, between 0.21-0.4 fair agreement, between 0.41-0.60 moderate agreement, between 0.61-0.80 good agreement and between 0.81 - 1 excellent agreement [15]. Confidence intervals were calculated to judge significance.

Finally we looked for differences in interpretation between the three disciplines: we counted the total number of normal and abnormal readings per discipline and checked if the number of abnormal readings was comparable between disciplines by means of the McNemar test, a test which compares paired proportions [16].

RESULTS

Eighty maxillary sinuses were read by 18 doctors, in total 1440 readings: in 50 % the readings were considered normal, 36% revealed mucosal swelling, 9% air- fluid level or total opacity and in 5% interpretation was considered impossible. In Table 1, a summary of the total results for the different classifications is presented.

There were no eccentric performers in any of the three doctors groups.

Table 2 shows the proportions of agreement and kappa-values for agreement for the three classifications.

In general we can see that the proportion of agreement is highest between readings of the radiologists and by far the lowest between readings of the general practitioners.

There is also a large difference in agreement according to the different classifications. For all three physician groups, the proportion of agreement is lowest for classification 1 and highest for classification 3: for classification 1 at least 4 of the 6 radiologists agree for 76% of the images, ENTs in 71% and GPs in 28 %; in classification 3 this is 99% for radiologists, 96% for ENTs and 86% for GPs.

In classification 2 as well as in classification 3 the ranges between the doctors with the highest and lowest number of normal readings or sinusitis readings are quite large.

After correction for chance agreement we see that agreement is still highest between radiologists, although ENTs again come very close. Agreement in the group of radiologists and ENTs is now, however, markedly higher in classification 2 than in 1 and 3, with kappa values being respectively 0.63 and 0.57 meaning (almost) "good agreement". For GPs agreement in classification 2 is still only "fair" with a kappa value of 0.30.

In table 3 we compared the frequencies of abnormal readings per discipline. This shows that abnormal readings are significantly more frequent when readings are performed by GPs than by radiologists or ENT surgeons.

Table 1. Result of interpretation of 80 Waters' views of the maxillary sinuses by 18 doctors.

1.normal = normal or slight mucosal swelling; sinusitis = important mucosal swelling, air fluid level, complete opacity.

2. normal = normal, slight mucosal or important mucosal swelling; sinusitis = air fluid level, complete opacity.

Classification 1	Number of readings (%)	Classification 21	Number of readings (%)	Classification 32	Number of readings (%)
Normal	724 (50,3)	normal	928 (64,4)	Normal	1239 (86,0)
Slight mucosal swelling	204 (14,2)				
Important mucosal welling	311 (21,6)				
Air fluid level	49 (3,4)	sinusitis	437 (30,3)	sinusitis	126 (8,8)
Total opacity	77 (5,3)				
Interpretation impossible	75 (5,2)	Interpretation impossible	75 (5,2)	Interpretation impossible	75 (5,2)
Total	1440 (100)	Total	1440 (100)	Total	1440 (100)

Table 2. Interobserver agreement between radiologists, ENTsurgeons and general practioners.

Classification 1 shows agreement between doctors when classifying radiographs in 6 categories : normal, slight mucosal swelling, important mucosal swelling, air fluid level, total opacity, interpretation not possible. Classification 2 and 3 shows results after ordening the readings into 3 categories : in classification 1 sinusitis is important mucosal swelling, air fluid level, complete opacity; in classification 3 sinusitis is air fluid level or complete opacity.

1 range between the doctor with the highest and the lowest number of normal readings

2 range between the doctor with the highest and the lowest number of sinusitis readings

3 GPs = general practitioners

4 Confidence Interval

	Proportion (number) of radiographs for which there is agreement (n=80)		Range normal 1	Range sinusitis 2	Kappa (95% CI4)
	All 6 agree	4/6 agree			
1. Radiologists					
classification 1	0.30 (24)	0.76 (62)			0.40 (0.36-0.44)
classification 2	0.59 (47)	0.95 (76)	45-62	18-24	0.63 (0.58-0.68)
classification 3	0.74 (59)	0.99 (79)	69-77	2-6	0.39 (0.35-0.44)
2. ENT-surgeons					
classification 1	0.25 (20)	0.71 (57)			0.38 (0.35-0.41)
classification 2	0.56 (45)	0.93 (74)	50-61	18-25	0.58 (0.53-0.63)
classification 3	0.66 (53)	0.96 (77)	65-76	2-11	0.37 (0.32-0.42)
3. GPs3					
classification 1	0.19 (15)	0.54 (43)			0.24 (0.21-0.27)
classification 2	0.28 (22)	0.79 (63)	35-59	35-59	0.30 (0.25-0.35)
classification 3	0.50 (40)	0.86 (69)	57-71	6-18	0.28 (0.23-0.33)

Table 3. Comparison of the number of sinusitis readings between disciplines.

Classification	Proportion of sinusitis readings (%)	McNemar test
1 ¹	RX 142/480 (30%)	RX versus ENT p= 0,182
	GP 165 / 480 (34%)	RX versus GP p= 0,040
	ENT 130/480 (27%)	ENT versus GP p= 0,002
2 ²	RX 25/ 480 (5%)	RX versus ENT p= 0,09
	GP 61/ 480 (14%)	RX versus GP p< 0,001
	ENT 34 / 480 (7%)	ENT versus GP p< 0,001

DISCUSSION

Our main finding is that the reproducibility of Waters' views of the maxillary sinuses of patients with suspected acute sinusitis is best - although still not excellent - when the interpretation is performed by radiologists or ENT surgeons, and when criteria for sinusitis are: important mucosal swelling, air fluid level or complete opacity. Interobserver agreement is only "fair" or less when more stringent criteria - air-fluid level or complete opacity - are used or when readings are performed by GPs.

As mentioned before, only four studies have previously studied interobserver agreement in the reading of sinus radiographs in adult patients. Two were on patients with chronic complaints. The first study [8] compared the interpretation of 84 radiographs by a radiologist and an ENT physician. The value of kappa was 0.49 meaning moderate agreement. A second investigation [10] considered the reading of 100 maxillary sinuses by two radiologists and two ENT surgeons. Agreement between the two radiologists was 0.58, and between the two ENT surgeons it was 0.45, meaning again moderate agreement. In both studies agreement is somewhat lower than in our study. This can probably be explained by the difference in population: radiographs of patients with long standing complaints might be more difficult to read and thus lead to less interobserver agreement [17]. Two studies were performed on patients with suspected acute sinusitis. In the study of Williams [9], in total 90 patients with sinus complaints of less than 3 months duration were studied. Criteria for abnormality were mucosal swelling of a least 6 mm, air-fluid level or complete opacity. Radiographs were read by 3 radiologists and compared one by one. Kappa values were 0.72 -0.80 showing good to excellent agreement. In the study of Blomgren [11], 50 radiographs were read by one radiologist and one ENT-surgeon. Radiographs were classified in three categories: mucosal thickening < 6 mm, mucosal thickening > 6 mm (no fluid), air-fluid level. Kappa value was 0.68, again showing good agreement. These kappa values are higher than in our investigation. This can be explained firstly by the fact that there were fewer observers who were moreover compared one by one: fewer observers decrease opportunities for disagreement; and secondly by the

fact that an exact definition of "important mucosal swelling" - >6 mm - was used in these studies: well-defined methods of measurement will give fewer differences between observers [17].

In the present study we wanted to measure interobserver agreement in "normal" clinical conditions: radiographs - just like in daily practice - were interpreted by doctors with different degrees of experience or working in different settings; readings were performed in the doctors' own practice or in comparable surroundings; and "important mucosal swelling" was defined in terms of consequence (i.e. sufficiently pathological to lead to further action) instead of millimetres. Although these factors will undoubtedly have reduced the interobserver agreement, we felt that the results would be closer to reality than results obtained in highly standardised circumstances. A single Waters' view was preferred to a four-view sinus series because in acute sinusitis the maxillary sinuses are almost always involved [18], and agreement between results of the four-view and single Waters' view is substantial for the maxillary sinuses [9]. Radiologists, ENT-surgeons and GPs, performed the readings because these are the doctors most frequently confronted with radiographs of the maxillary sinuses and/or patients with acute sinusitis. It has been shown that between radiologists and physicians or surgeons experienced in the context of the cases being examined, there is little difference in performance in reading radiographs [19, 20]. This is confirmed by our study, which shows that interobserver agreement between ENT surgeons is only slightly less than between radiologists. GPs on the other hand diagnose and treat more than 90% of all acute sinusitis cases [21] but in Belgium they lack the specific training and experience to read sinus radiographs, which probably explains the bad agreement. This lack of radiological experience might also explain the significantly higher number of abnormal readings by GPs.

We found that the best interobserver agreement is seen when important mucosal swelling is added as diagnostic criterion for sinusitis. This does not mean that all patients with mucosal swelling should be considered as suffering from acute sinusitis. Mucosal swelling indicates generally only an extension of a

nasal inflammatory process to the sinus mucosa. In the common cold for example mucosal abnormalities are so frequent that a common cold can be considered as a viral "rhinosinusitis" instead of rhinitis [22]. However, including the criterion "mucosal swelling" increases the sensitivity of radiology for detecting sinusitis to 90%: in a meta-analysis of studies on the diagnostic value of radiology in comparison with a gold standard (sinus puncture) about 10 % of patients with mucosal swelling also have fluids in this maxillary sinus [7].

The meaning of our results for daily practice is that the Waters' view of the maxillary sinuses - on condition that they are read by doctors trained in ENT-radiology - can be used with confidence to rule out sinusitis. When confronted with a patients with ambiguous complaints possibly related to the sinuses (e.g. headache, rhinorrhea or night cough) absence of mucosal swelling, air-fluid level or complete opacity permits to eliminate acute maxillary sinusitis from the list of possible diagnoses with a high degree of certainty: the known high sensitivity combines with a good interobserver agreement. On the other hand, the results illustrate that Water's view of the maxillary sinuses is less suitable for diagnosing sinusitis and thus underpin the current practice guidelines. Verifying a suspected diagnose requires a test with a high specificity and a low chance of false positive results. In case of sinus radiology this means that the more stringent radiographic criteria for sinusitis, namely "fluid level or complete opacity" - with a specificity of 80% [7] - must be used. Yet, for these criteria we have shown that interobserver agreement is unacceptably low, even between experienced readers.

Alternatives for diagnosing acute sinusitis may be history and physical examination, possibly combined with measurement of CRP or ESR, ultrasonography, or CT-scan. Yet, all have shortcomings as well: history, physical examination, CRP, ESR and ultrasonography have a limited diagnostic value when compared with a gold standard [18, 23, 24, 25, 26, 27, 28]. CT-scan is expensive and not everywhere within reach of primary care. Moreover, recent studies show that in the majority of patients with clinically suspected sinusitis [12, 29, 30, 31], or with abnormalities on sinus radiographs [32], or with elevated CRP or ESR [33], or even with abnormalities on CT-scan [34, 35] antibiotics are not effective. In this study we tried to show that plain radiographs could be suitable for ruling out acute sinusitis. Which test is the most suitable for ruling in acute sinusitis will not only depend on its accuracy and reproducibility, but mainly on its effectiveness, namely to what extent the test outcome will influence the patient outcome by altering decisions on treatment.

CONCLUSION

Choosing the right diagnostic examination always requires careful outweighing of benefits and costs. The most sophisticated tests may not always be the most rational choice. With this study we demonstrate that the Waters' view can still be a cheap, safe and readily accessible investigation when the indication is

mainly to rule out acute maxillary sinusitis, because it not only has a high sensitivity but also a sufficient reproducibility.

ACKNOWLEDGEMENTS

We wish to thank for their invaluable help: Christaens T MD PhD, Bauters W MD, Claeys S MD and all Radiologists, ENT surgeons and General Practitioners who were so kind to participate in this investigation.

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