

Inter-Observer and Intra-Observer Variability In the Assessment of The Paranasal Sinuses Radiographs

A Norie, R Ahmad, W Liew, M Zahiah

Citation

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Abstract

The aims of this study are to determine the intra-observer and inter-observer agreement between the two radiologists when reporting the Waters view and 3 views series of the paranasal sinus radiographs. To also determine whether a single Waters view is adequate for diagnostic purpose of sinusitis. 90 sets of paranasal sinuses radiographs were reported by two radiologists independently. The results revealed that the intra-observer and inter-observer agreement varied from almost perfect to good for maxillary and frontal sinuses, but poor for sphenoid and ethmoidal sinuses. Therefore, a single waters view is an acceptable strategy for diagnosing sinusitis for the maxillary and/or frontal sinuses but not for the ethmoid and sphenoid sinuses.

INTRODUCTION

Infections of the paranasal sinuses are commonly seen especially in the outpatient department. The nonspecific clinical presentations of paranasal sinuses infection challenge the clinician to try and ascertain the correct diagnosis. Plain film radiography of the paranasal sinuses is a rapid and safe test often used to confirm the diagnosis. It is the most frequent initial study to be obtained because of its comparatively low cost, availability and easy examination. Traditionally, three projections are used in the plain film assessment of the paranasal sinuses. These include the Waters (occipitomeatal), Caldwell (occipitofrontal) and lateral views. This is the current practice in many centers including in the authors center. While the use of the Waters projection as the single view to diagnose sinusitis has been suggested in some centers, the feasibility of this approach has not been widely established.

In one study comparing the Waters view with three views, 99% agreement was obtained concluding that a single Waters view is sufficient for diagnostic purposes.¹ Another similar study also concluded that by substituting a single Waters view instead of a four-view sinus series is an acceptable strategy for diagnosing maxillary sinusitis.² Potential advantages of the single view include lower costs, time saving and decrease radiation exposure.^{2,3,4,7} The result of a multicentre study of radiographic practice, showed that if the Caldwell and lateral projection were omitted from the sinus examination, the mean exposure from the examination

might be reduced by 55%.⁵ The main purpose of this study is to determine whether a single Waters view is adequate for diagnosing sinusitis when compare to the traditional three-views series.

Clinically significant ethmoid sinus disease may be present with relatively minimal findings on plain film radiography. When viewed on conventional projections, the ethmoids have many cells superimposed upon one another. The superimposition can lead to confusion as the disease cells may be masked, giving the appearances of a completely normal ethmoid sinus. The maxillary sinuses deserve particular attention because statistically they are most often affected by infection. The Waters view is the best projection for evaluating the maxillary sinuses (Figure 1). True mucosal changes extend along the adjacent lower lateral antral wall and it is there that such mucosal disease should be evaluated.⁶ The sphenoid sinuses are the most difficult sinuses to evaluate on plain film radiography because they are positioned deep in the skull base with different structures overlapping them on each view of the sinus series. The best view for visualizing the sphenoid sinus is the submentovertex view.

The inflammatory changes are similar in all paranasal sinuses. During acute stages the membranous lining become swollen, secondary to oedema and congestion. The air space of the sinus is reduced peripherally by the swelling of the walls and is partially or completely filled with fluid. These reactions commonly seen during upper respiratory tract

infections. There is most often asymmetric sinus involvement with one or several unilateral sinuses affected. The coexistence of bacterial and allergic sinusitis is not uncommon. Profused secretions associated with nasal obstruction can result in some retained secretions and eventual infection. In general, asymmetric sinusitis is a hallmark of bacterial disease. The plain film findings of bacterial disease are those primarily those of mucosal thickening, an air-fluid level, total sinus opacification and in chronic cases, reactive, thickened sclerotic sinus walls.

Figure 1

Figure 1: Waters (occipitomeatal) view of the paranasal sinus.



Figure 2

Figure 2: Waters view (above) and Caldwell view (below) for patient no. 11. Patient was diagnosed to have ethmoid sinusitis on Water view but normal on three view series.

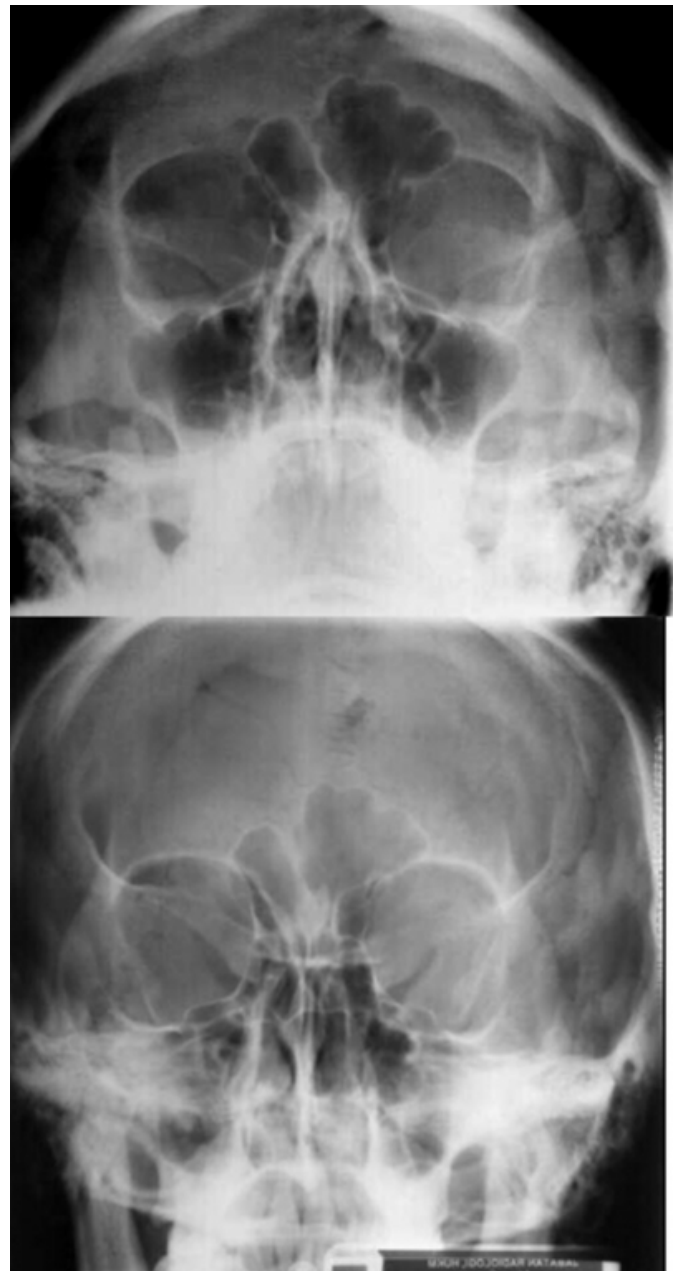


Figure 3

Figure 3: Waters view (above) and Caldwell view (below) for patient no. 34. Patient was diagnosed to have ethmoid sinusitis on Water view but normal on 3 view series.

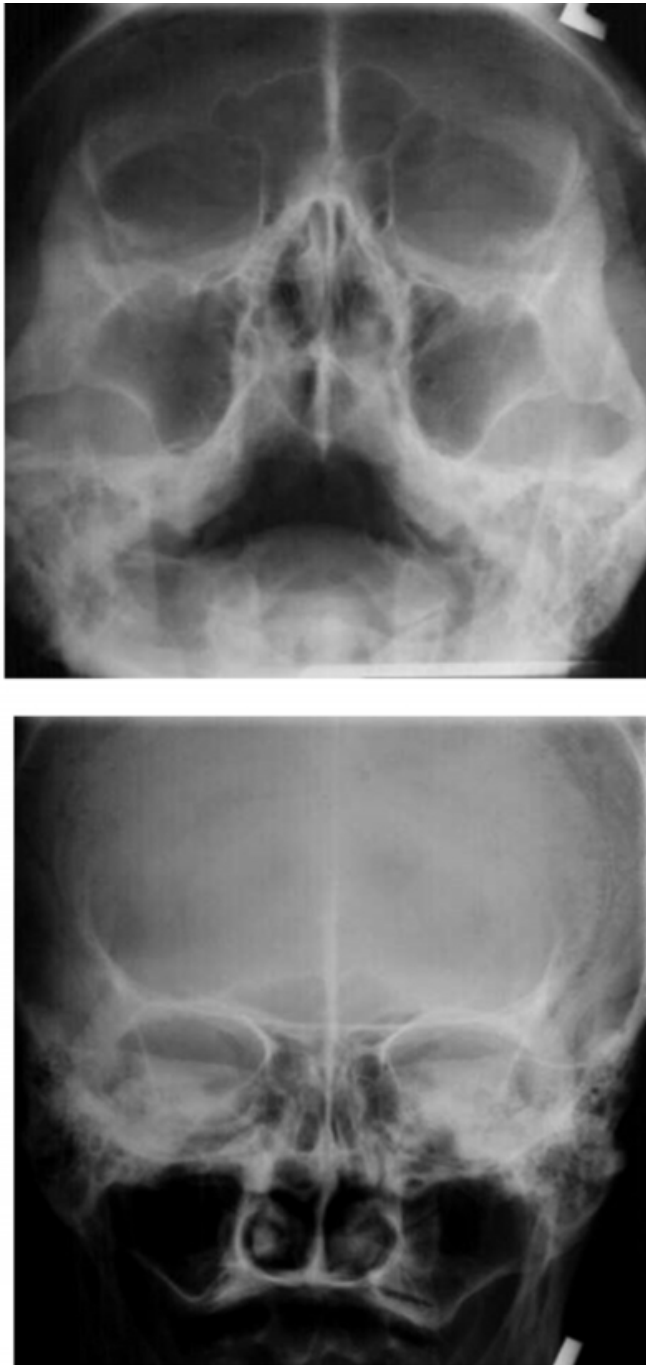


Figure 4

Figure 4: Waters view (above) and Caldwell view (below) for patient no. 80. Patient was diagnosed to have bilateral maxillary and ethmoid sinusitis by R1, but only maxillary sinusitis by R2 in Waters view only.



MATERIALS AND METHODS

This is prospective study where ninety sets of paranasal sinus radiographs of patients were obtained from January till December 2002. Patients who reported symptoms of rhinorrhea, facial pain unrelated to trauma or suspected sinusitis were included and three sinus projections were obtained for each patient. The standard three projections

used in the assessment of the paranasal sinuses were the Waters (occipitomeatal) view, the Caldwell (occipitofrontal) view and the lateral view. Patients with acute facial or head trauma, previous sinus surgery or immunocompromised were excluded.

Two radiologists coded as R1 and R2 respectively were involved in reporting these 90 sets of plain sinus radiographs. They had no access to clinical information including the patient's name. Each radiologist was asked to evaluate a single Waters view first and later, the 3 views series on different occasions. The radiologists were given no time constraint and no precise time limit was given. The time interval between the 2 reporting sessions were between 3 days to 2 weeks. Each observer was asked to analyse each sinus and give the impression of the radiograph according to the given data collection sheet (Appendix I). A diagnosis of sinusitis is based on the accepted radiographic criteria of an air fluid level, complete sinus opacity or mucosal thickening (≥ 6 mm for maxillary sinuses).

The intra-observer agreement is an index of intra-observer variability which is obtained when observer, observed the same item twice and the observations were compared. The inter-observer agreement is an index of variability when the interpretation by one observer is compare with those of the other. Simple agreement (SA) is defined as the proportion of times that one observer interprets the Waters view and the 3 view the same way or the two observers make the same interpretation. Simple agreement may exaggerate the true level of concordance, thus the chance of agreement is corrected with the kappa (K) statistical analysis.

Kappa is defined as the proportion of agreement within the observer or between observers, after chance agreement has been removed and is expressed symbolically by the following equation: $Kappa = \frac{\text{Proportion of observed agreement} - \text{Chance agreement}}{1 - \text{Chance agreement}}$. A Kappa value with a score of 1.0 indicates perfect agreement, a score of zero indicates agreement that is not better than expected by chance and a negative value indicates agreement that is worse than expected by chance (Table 1).

The P value for kappa refers to the probability that agreement is different from that expected by chance. The highly significant P values for kappa that we report demonstrate that the agreement found is significantly different from that expected by chance. They do not indicate the level of agreement. Statistical calculations were

performed using the SPSS statistical software.

RESULTS

A total of 90 sets of paranasal sinus radiographs were reviewed by 2 radiologists. The overall prevalence of sinusitis among the 90 patients was 33% (n = 30 patients).

50% had unilateral or bilateral maxillary sinusitis. 37% had maxillary sinus disease with changes in at least one other sinus. 6% each had isolated frontal and ethmoid sinuses changes. No patient had isolated sphenoid sinus.

Intra-observer agreement - Waters views versus 3 views series for R1 & R2 (Table 1 & 2). Agreement between the Waters view and 3 views series was substantial (SA = 90% and 98%, K = 0.78 and 0.71, $P < 0.001$ for R1 and R2 respectively). Further analysis of each sinus, the agreement was almost perfect for maxillary sinuses (SA = 97 – 98%, K = 0.86 – 0.97, $P < 0.001$). For the frontal sinuses the agreement was substantial to almost perfect for R1 (SA = 98%, K = 0.79 – 0.88, $p < 0.005$) and fair to moderate for R2 (SA = 97-98%, K = 0.31 – 0.55, $p < 0.001$). There was poor agreement for the ethmoid sinuses (SA = 57 - 81%, K = 0.05 – 0.21, $p = 0.002 - 0.017$) and sphenoid sinus (SA = 78 – 79%, K = 0.08 – 0.13, $p = 0.012 - 0.06$) for both radiologists.

Inter-observer agreement – R1 versus R2 for Waters and 3 views series (Table 3 & 4). The agreement was substantial for both the Waters and 3 views series when the sinuses were analyzed for the presence or absence of sinusitis. (SA = 86 - 88%, K = 0.69 – 0.71, $p < 0.001$). When only the maxillary sinuses were analyzed, the agreement was almost perfect (SA = 94 -98%, K = 0.75 - 0.94, $p < 0.001$). For the frontal sinuses the agreement was substantial for Water view (SA = 90-91%, K = 0.65 – 0.79, $p < 0.001$) and moderate to substantial for 3 views series (SA = 97 -98%, K = 0.55 – 0.66, $p < 0.001$). There was poor to fair agreement for the ethmoid sinuses for both the Waters and 3 views series (SA = 60- 91%, K = 0.17 – 0.24, $p = 0.001 - 0.039$). For the sphenoid sinus the inter-observer agreement was good (SA = 89 - 98%, K = 0.66 – 0.69, $p < 0.001$).

Figure 5

Table 1: Kappa value related to strength of agreement.

Value of Kappa	Strength of agreement
< 0.20	Poor
0.21 – 0.40	Fair
0.41 – 0.60	Moderate
0.61 – 0.80	Good
0.81 – 1.00	Excellent

Figure 6

Table 2: Intraobserver agreement for Waters versus 3 views series for R1 (first radiologist)

Sinuses examined	Simple agreement	Kappa	P value
Maxillary Right Left	98%	0.97	< 0.001
	97%	0.86	< 0.001
Frontal Right Left	98%	0.88	< 0.001
	98%	0.79	< 0.001
Ethmoid Right Left	77%	0.17	< 0.001
	81%	0.21	0.002
Sphenoid	78%	0.13	0.012
All	90%	0.78	< 0.001

Figure 7

Table 3: Intraobserver agreement for Waters versus 3 views series for R2 (second radiologist)

Sinuses examined	Simple agreement	Kappa	P value
Maxillary Right Left	98%	0.94	< 0.001
	98%	0.94	< 0.001
Frontal Right Left	97%	0.55	< 0.001
	96%	0.31	0.002
Ethmoid Right Left	57%	0.11	0.017
	61%	0.05	0.281
Sphenoid	79%	0.08	0.06
All	88%	0.71	< 0.001

Figure 8

Table 4: Interobserver agreement between R1 and R2 for single Waters view (n = 90)

Sinuses examined	Simple agreement	Kappa	P value
Maxillary Right Left	94%	0.85	< 0.001
	94%	0.75	< 0.001
Frontal Right Left	98%	0.66	< 0.001
	97%	0.55	< 0.001
Ethmoid Right Left	60%	0.24	0.001
	62%	0.18	0.02
Sphenoid	89%	0.69	< 0.001
All	86%	0.69	< 0.001

Figure 9

Table 5: Interobserver agreement between R1 and R2 for 3 views series

Sinuses examined	Simple agreement	Kappa	P value
Maxillary Right Left	98%	0.94	< 0.001
	97%	0.82	< 0.001
Frontal Right Left	97%	0.65	< 0.001
	98%	0.79	< 0.001
Ethmoid Right Left	91%	0.17	0.039
	90%	0.21	0.011
Sphenoid	98%	0.66	<0.001
All	88%	0.71	< 0.001

DISCUSSION

Previous study has shown that there was 99% agreement for the Waters view versus the three views series of paranasal sinus radiographs and concluded that a single Waters view is sufficient for diagnostic purpose of sinusitis.¹ However, this study was exaggerated by reporting only simple agreement without correction for chance agreement, which is shown by the Kappa value. Kappa statistic is important not only to present the level of percentage agreement but also make an adjustment for the amount of agreement that can be expected by chance alone.² Furthermore, the inter-observer and intra-observer agreement which measures the reproducibility of the observers' interpretations were not described in the study. This is important as the variability of a test is measured by its reproducibility.⁸

Another study which is similar to this study, has established the reproducibility of radiographic interpretations by measuring the inter-observer and intra-observer variability.² They also concluded that the single Waters view achieved good agreement with the complete sinus series. However, after correcting for chance agreement, the agreement varied depending on which sinus was involved.

As for this study, the intra-observer agreement between Waters versus three views for both radiologist 1 (R1) and radiologist 2 (R2) was almost similar. The agreement was varied according to the sinuses. The agreement was excellent for the maxillary sinuses, fair to substantial for frontal sinuses and poor for the ethmoid and sphenoid sinuses. These results were consistent with the previous study stated above.

The reason for the wide variation of agreement between these sinuses is because the Waters view, images the maxillary sinuses better than the frontal, ethmoid and sphenoid sinuses.^{4,7} For example in patients no 11 and 34, in which both radiologist diagnosed as ethmoid sinusitis in Waters view but normal in three views series (figure 2, 3). This study indicates that there was similar agreement between the R1 and R2 in evaluation of the Waters views alone and the three views series in separate occasions.

The inter-observer agreement revealed the same pattern of agreement as the intra-observer agreement. The inter-observer agreement between R1 and R2 was excellent to substantial for the maxillary, frontal and sphenoid sinuses. However, the agreement was poor for the ethmoid sinuses. This indicates that there was disagreement between the R1 and R2 in assessing the ethmoid sinuses. The reason for this is due to the overlapping ethmoid sinuses with the adjacent bony structures that cause the difficulty in assessing the sinuses by both radiologists. Superimposed bony shadows may give an appearance indistinguishable from mucosal thickening.⁹ For example in patient no 80, in which R2 diagnosed as maxillary and ethmoid sinusitis while R1 diagnosed as only maxillary sinusitis (figure 4). Another explanation for the poor agreement in the non-maxillary sinuses is that the criteria used for abnormality of these sinuses were less precise than the criteria used for abnormality in the maxillary sinuses.

The inter-observer variant is recognized and should be kept to a minimum. This would lead to a more consistent approach to patient assessment and management.⁸ The varying degree of agreement, of different sinuses has important implications for the clinician who requests a single Waters view to diagnose sinusitis. Correct diagnosis depends not only on the Waters view's concordance with the 3 views series but also on the prevalence of maxillary involvement.²

In this study, more than 50% of patients with sinusitis had maxillary disease. This is consistent with other studies, which revealed that maxillary sinusitis either in isolation or with involvement of other sinuses is by far the most common.^{2,7} Therefore, most patients with sinusitis would have been diagnosed with the Waters view only.

In cases of clinically suspected sinusitis, the Waters view should be the basic projection since it discloses the maxillary sinuses more confidently than other projections.⁷ It also gives additional reliable information on the frontal sinus. If

the findings are normal, no further views are needed. The Caldwell or occipitofrontal view demonstrates the frontal and ethmoid sinuses, and should remain a routine projection in suspected frontal or ethmoid sinus changes and in those cases where the evaluation of these sinuses is difficult to interpret in the Waters view. The lateral projection can be eliminated since the inflammatory changes in the sphenoid sinus are apparently rare.⁷ Previous study noted that the lateral view did not contribute any additional information.¹

Potential advantages of a single Waters view include lower costs, decrease radiation exposure and time saving for staff and patient.^{2,4} The result of multicentre study of radiographic practice showed that if the Caldwell and the lateral views were omitted, the mean exposure from the examination can be reduced by 55%.⁵ Choice of the minimal number of projections consistent with the desired clinical results will obviously ensure that radiation protection is optimised.

There are several limitations recognized in this study. Recall bias which generally acts to increase agreement may be present as the Waters view is one of the projection in the three views series. This bias was minimized by masking the patient identifications and separating the reporting sessions. In this study, the time interval between the two reporting session was more than three days. Furthermore, inappropriate time allocation for reporting could also contribute to the variation of the observers in reporting. Unsatisfactory quality of the radiographs may cause misinterpretation by the observers. This is because of no special attention given to monitor the quality of the paranasal sinus radiographs. The reasons for this radiological inaccuracy are manifold, some are inherent such as superimposition of structures other than sinuses, sloping sinus wall, irregular dimensions of sinuses, asymmetry between two sides ¹⁰. Some are technical such as slight rotation or angulation and improper positioning and exposure. Nevertheless, with greater attention to the radiographic technique, the Waters view alone is sufficient for diagnostic purpose of sinusitis.

CONCLUSION

The intra-observer agreement between Waters and 3 views series, varied from almost perfect and good agreement for the maxillary and frontal sinuses to poor agreement for the ethmoid and sphenoid sinus. The inter-observer agreement between the 2 radiologists, varied from the almost perfect and good agreement for the maxillary, frontal and sphenoid sinus to poor agreement for the ethmoid sinus. A single

Waters view is an acceptable strategy for diagnosing sinusitis if there is clinical suspicious of maxillary and/or frontal sinusitis but not for the ethmoid and sphenoid sinuses.

Figure 10

Appendix 1

DATA SHEET

Study No.:

X-ray No.:

Radiologist: 1. 2.

Study series: OM ----- Three-view-----

Radiographic findings

Paranasal sinuses	Normal	Mucosal thickening	Air-fluid level	Opaque	Unable to comment
1. Maxillary Left Right					
2. Frontal Left Right					
3. Ethmoid Left Right					
4. Sphenoid Left Right					

Radiological diagnosis: 1. Normal -----

2. Sinusitis -----

Comment: -----

CORRESPONDENCE TO

Raja Ahmad MS (ORL-HNS) Dept. of Otolaryngology – Head & Neck Surgery, Faculty of Medicine, International Islamic University Malaysia, Jalan Hospital, 25100, Kuantan, Pahang, Malaysia. Tel: 609-5132797 Fax: 609-5133615 E-mail: rahmad@iiumedic.edu.my / rlahmad@gmail.com

References

- Hayward, M. W. J., Lyons, K., Ennis, W. P., Rees, J. 1990. Radiography of the paranasal sinuses - one or three views? *Clinical Radiology* 41:163-164.
- Williams, J. W. Jr, Roberts, L. Jr, Distell, B., Simel, D.L. 1992. Diagnosing sinusitis by X-ray: Is a single Waters view adequate? *J General Internal Medicine* 7(5): 481- 485.
- Ros, S. P., Herman, B. E., Azar-Kia, B. 1995. Acute sinusitis in children: is the Water's view sufficient? *Pediatric Radiology* 25(4):306-307.
- Macleod, B. Paranasal sinus radiography. 1991.

Emergency Medicine Clinics of North America
9(4): 743-755.

5. Matthews, I. P., Rogers, K. D. 1988. Prevention of radiogenic cancer through change in procedure. *Radiography* 54:3-8.

6. Som, P. M., Curtin, H. D. 1996. *Head and Neck Imaging*. Volume one. Third edition. New York. Mosby.

7. Axelsson, A., Jensen, C. 1974. The roentgenologic demonstration of sinusitis. *American Journal of Roentgenology* 122: 621- 627.

8. Tudor, G. R., Finlay, D., Taub, N. 1997. An assesment of inter-observer agreement and accuracy when reporting plain radiographs. *Clinical Radiology* 52: 235-238.

9. Wilson, P. S, Grocutt, M. 1990. Mucosal thickening on sinus x-rays and its significance. *J laryngology and Otology* 104:694-695.

10. Iinuma T, Hirota Y, Kase Y. 1994. Radio-opacity of the paranasal sinuses. Conventional views and CT. *Rhinology* 32:134-136.

Author Information

A. Norie, MM (Radiol.)

Department of Diagnostic Imaging, Hospital Tengku Ampuan Afzan Kuantan

R. Ahmad, MS (ORL-HNS)

Department of Otolaryngology-Head & neck Surgery, Faculty of Medicine, International Islamic University Malaysia

W. F. Liew, MM (Radiol.)

Department of Radiology, Faculty of Medicine, National University of Malaysia

M. Zahiah, MM (Radiol.)

Department of Radiology, Faculty of Medicine, National University of Malaysia