Eur Arch Otorhinolaryngol (2009) 266:519–525
DOI 10.1007/s00405-008-0786-6

RHINOLOGY

Appropriate interslice gap for screening coronal paranasal sinus tomography for mucosal thickening

Can Alper Cagici · Cuneyt Yilmazer · Cem Hurcan · Cem Ozer · Fulya Ozer

Received: 29 January 2008 / Accepted: 22 July 2008 / Published online: 8 August 2008

Abstract The objective of this study was to establish the appropriate interslice gap for screening coronal paranasal sinus tomography to identify sinus mucosal thickening. We reviewed 100 coronal paranasal sinus tomographic scans (interslice gap, 2 mm) that had been performed at our institution between January 2004 and November 2004 to evaluate rhinosinusitis. Digital photographs of all slices from each tomographic scan were taken. The intervening slices were eliminated to form six different sets of interslice gaps of 4, 6, 8, 10, 16, and 20 mm. The remaining slices for each set were moved to corresponding folders created on a computer to catalog each interslice gap. The same specialist evaluated each folder of interslice gap. The paranasal sinuses, the ethmoid infundibulum, and the frontal recess were evaluated for mucosal thickening. The sensitivity, specificity, and accuracy of each interslice gap in detecting mucosal thickening were calculated by accepting the results of 2-mm-thick slices as the gold standard. The interslice gap of 2 mm was compared with that of other interslice gaps using the chi-square test for dependent groups (the McNemar test). The value of 20 mm interslice gap in detecting sinus mucosal thickening was found to be significantly low when compared with the interslice gap of 2 mm ($P = 0.022$). Using coronal paranasal sinus tomography, an interslice gap up to 16 mm may be used to detect sinus mucosal thickening.

Keywords Tomography · Sinus · Diagnosis · Rhinosinusitis

Introduction

Rhinosinusitis is a common condition for patients who frequently seek treatment. However, diagnosing rhinosinusitis is often a significant challenge for physicians because diagnostic criteria for that disorder have not been established. Although the multidisciplinary Rhinosinusitis Task Force of the American Academy of Otolaryngology-Head and Neck surgery has established a symptom-based definition of rhinosinusitis, diagnosis with this method has been proven to be inaccurate [1–4]. For this reason, researchers have sought to define new criteria for the diagnosis of rhinosinusitis. The Task Force of the Sinus and Allergy Health Partnership has stated that at least one sign of inflammation (e.g., discolored nasal drainage, nasal polyps, polypoid swelling, or edema or erythema of the middle meatus or the ethmoid bulla) must be present during anterior rhinoscopy, along with ongoing symptoms, must be present for a diagnosis of rhinosinusitis [5]. The Task Force also stated that endoscopic examination and paranasal sinus computed tomography (CT) scan are helpful in confirming the diagnosis of chronic rhinosinusitis [5].

For evaluating the coronal plane, 3- to 5-mm interslice gaps are usually used in paranasal sinus CT scans [2, 6–13].

This article was presented as a poster at the 29th Turkish National Congress of Otorhinolaryngology and Head and Neck Surgery, May 26–31, 2007, in Antalya, Turkey.

C. A. Cagici (✉) · C. Yilmazer · C. Ozer · F. Ozer
Otorhinolaryngology Department,
Baskent University Faculty of Medicine,
Adana Teaching and Medical Research Center,
Baraj Yolu 1. Durak, Seyhan, Ankara 01150, Turkey
e-mail: ccagici@hotmail.com

C. Hurcan
Radiology Department,
Baskent University Faculty of Medicine,
Adana Teaching and Medical Research Center,
Baraj Yolu 1. Durak, Seyhan, Ankara 01150, Turkey

However, paranasal sinus CT is expensive, and this may limit its use in diagnosing rhinosinusitis. Screening CT protocols that use thicker sections (5 mm–1 cm) may be helpful in confirming the diagnosis of rhinosinusitis, which is the most frequent condition for which examination via a paranasal sinus CT is requested [14–16]. In this way, the cost of paranasal sinus CT scans and exposure of the patient to radiation can be reduced. However, the appropriate interslice gap for paranasal CT scans used in such screening has, to our knowledge, not been determined. We designed this study to compare the sensitivity, specificity, and accuracy of various interslice gaps in detecting mucosal thickening of the paranasal sinuses.

Materials and methods

A total of 100 coronal paranasal sinus CT scans that had been performed between January and November 2004 at our institution to identify rhinosinusitis were retrospectively evaluated. All coronal paranasal sinus CT scans had been obtained according to our standard coronal paranasal tomography protocol (i.e., high-resolution coronal slices 2-mm-thick acquired in 3-mm increments from the anterior wall of the frontal sinus to the posterior wall of the sphenoid sinus).

Digital photographs of all slices of each tomographic scan were taken. We sought to obtain six sets of slices with 4, 6, 8, 10, 16, and 20 mm gaps. Intervening 2-mm slices were discarded from the digital photographs of the coronal paranasal sinus CT scans (Figs. 1, 2, 3, 4, 5, 6, 7). We created seven different computer-generated folders that were named according to interslice gaps (2, 4, 6, 8, 10, 16, or 20 mm). The selected slices for each interslice gap were moved to their respective folder. Folders for all patients were created and were then numbered randomly. The same specialist evaluated the frontal, maxillary, sphenoid, anterior, and posterior ethmoid sinuses; the ethmoid infundibulum, and the frontal recess in each of the seven sets of coronal paranasal sinus CT scans and recorded the findings. All sets of coronal paranasal sinus CT results for each patient were entered into a computer database. During slice analysis, the examiner was blinded to the patients' clinical presentation. Mucosal thickening of more than 2 mm was considered to be abnormal. If mucosal thickening was present at any anatomic location, the results of the coronal paranasal sinus CT scan were accepted as positive overall. To

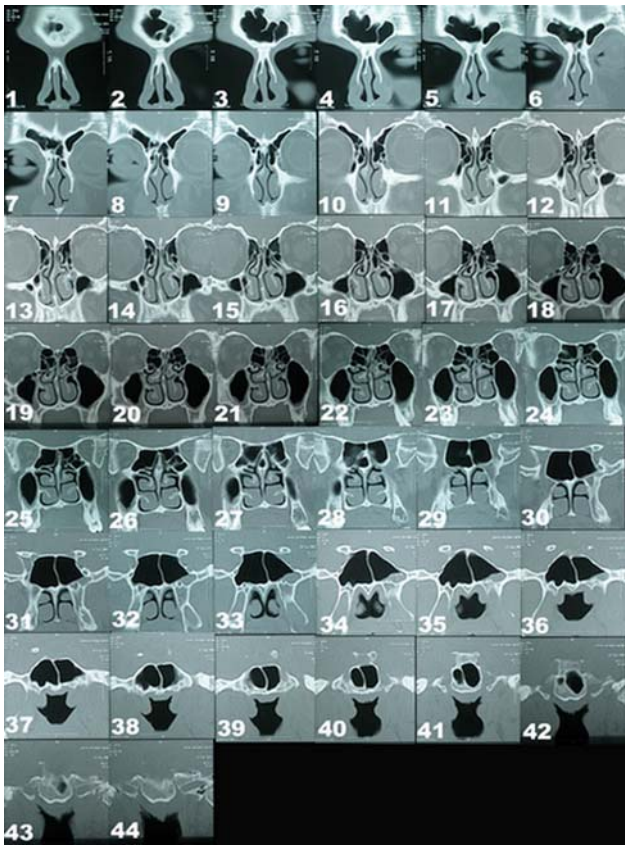

Fig. 1 Digital photographs of all slices of the 2-mm coronal paranasal sinus CT scans. All slices were *numbered* starting from the first slice just posterior to the anterior wall of frontal sinus

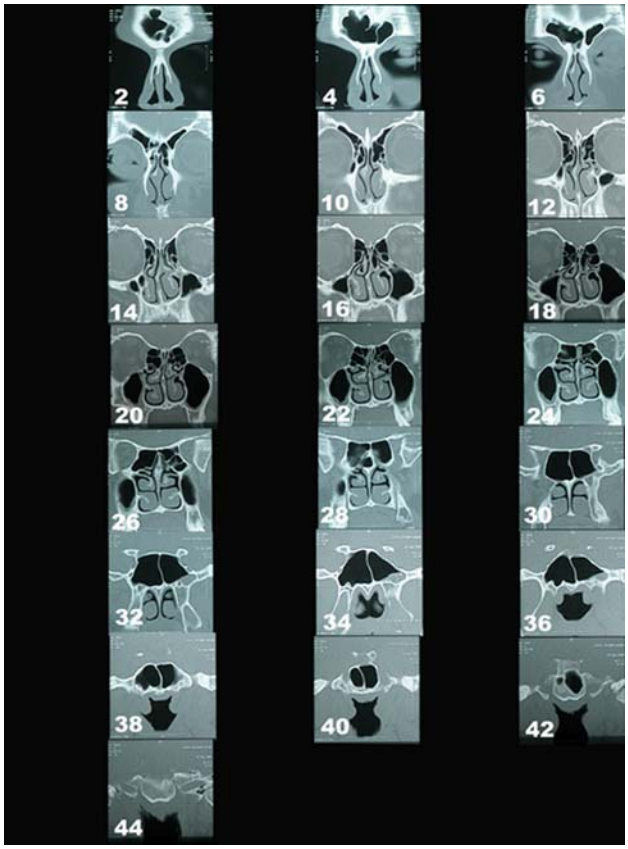

Fig. 2 To obtain a 4-mm interslice gap, one 2-mm intervening slice was discarded between two consecutive digital photographs of the coronal paranasal sinus CT scans

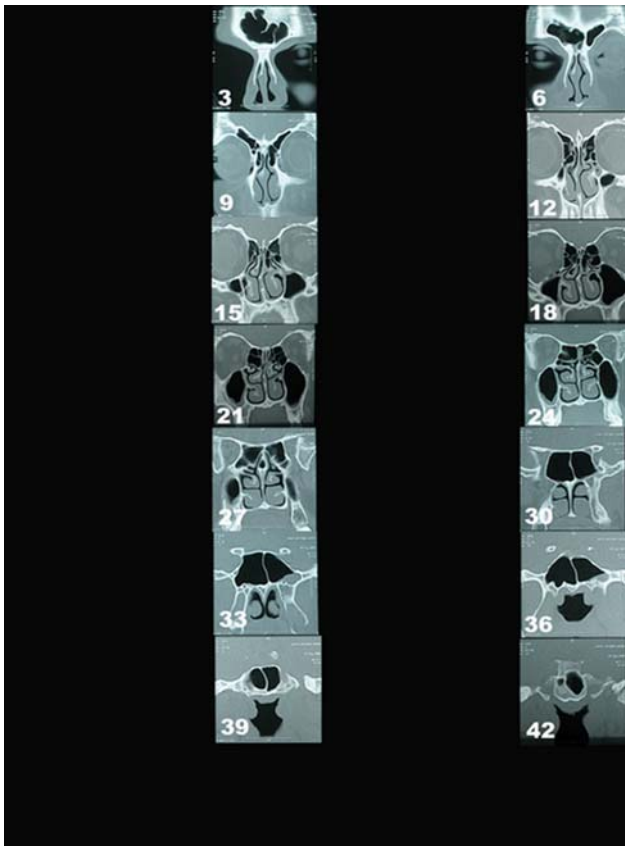

Fig. 3 To obtain a 6-mm interslice gap, two 2-mm intervening slices were discarded between three consecutive digital photographs of the coronal paranasal sinus CT scans

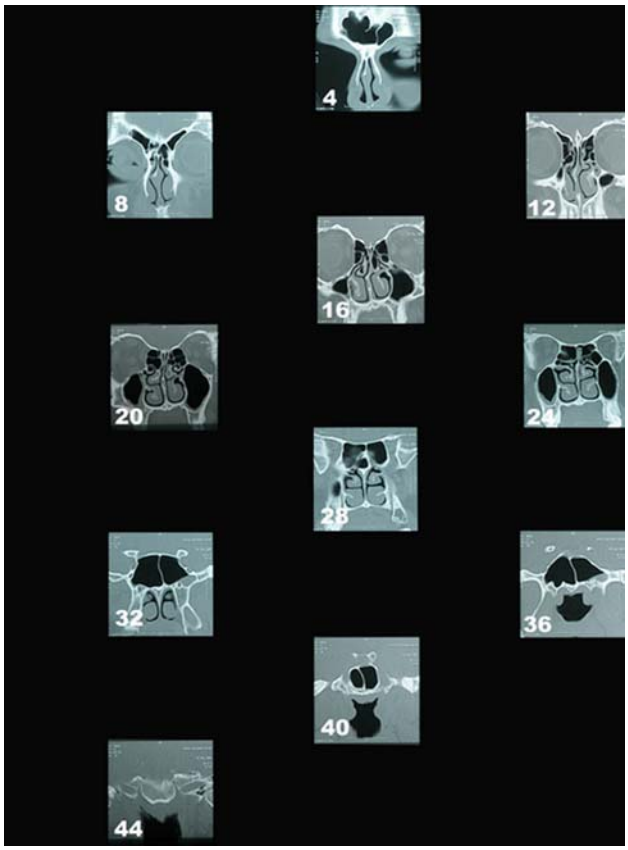

Fig. 4 To obtain an 8-mm interslice gap, three 2-mm intervening slices were discarded between four consecutive digital photographs of the coronal paranasal sinus CT scans

assess the diagnostic performance of each set of coronal paranasal sinus CT scans in detecting mucosal thickening, we calculated the sensitivity, specificity, and accuracy of each interslice gap using a 2-mm coronal paranasal sinus CT scan as the gold standard. The chi-square test for dependent groups (the McNemar test) was used. A P value of <0.05 was considered to be statistically significant.

Results

Using the 2-mm coronal paranasal sinus CT scan, 94 of the 100 patients (94%) had mucosal thickening in one of the sinuses studied. The correlation of tomographic findings of various interslice gaps with an interslice gap of 2 mm is presented in Table 1. The sensitivity, specificity, and accuracy of the six sets of coronal paranasal sinus CT scans in detecting mucosal thickening is shown in Table 2. With respect to the results of overall examination, the accuracy of 4, 6, 8, 10, 16, and 20 mm interslice gaps was found to be 96, 93, 91, 95, 90, and 87%, respectively. The sensitivity of 4, 6, 8, 10, 16, and 20 mm interslice gaps was found to be 98.9, 97.9, 93.6, 97.9, 91.5, and 88.3%, respectively. The value of 20 mm interslice gap in detecting sinus mucosal thickening was found to be significantly low when compared with the interslices gap of 2 mm ($P = 0.022$). With respect to the results of the overall examination, the difference between interslice gap of 2 mm and that of other interslice gap was not statistically significant.

Discussion

In 1997, the multidisciplinary Rhinosinusitis Task Force advised using a symptom-based definition for rhinosinusitis and stated that the patient's medical history and the results of physical examination were sufficient for diagnosing rhinosinusitis [1]. The Task Force also stated that nasal endoscopy and paranasal sinus CT scanning were expensive techniques that were not essential for the initial diagnosis of rhinosinusitis [1]. However, in 35–53% of the patients diagnosed as having rhinosinusitis according to the Task Force definition, the results of a paranasal sinus CT scan are within normal limits [2–4]. Consequently, the accuracy of a symptom-based diagnosis for rhinosinusitis is questionable and may result in inappropriate use of antibiotic

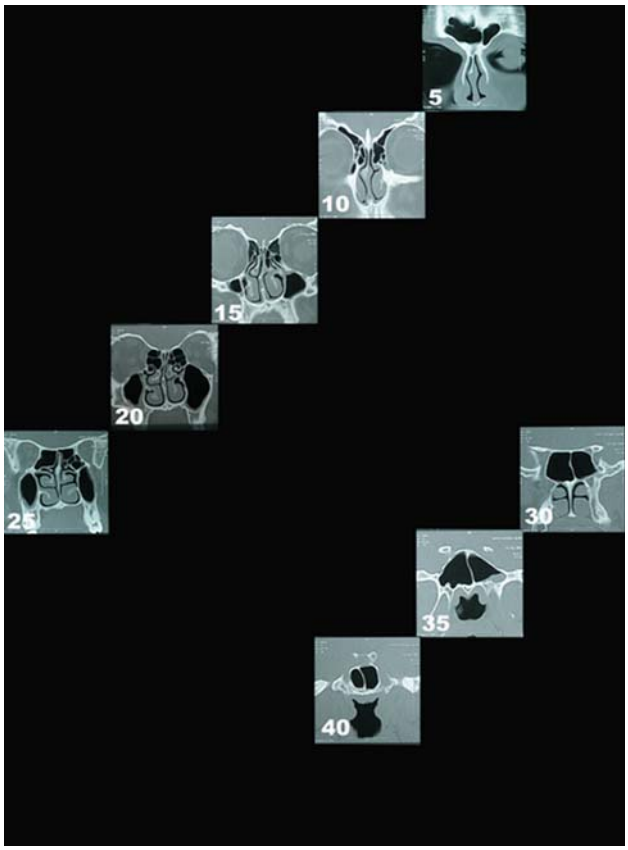

Fig. 5 To obtain a 10-mm interslice gap, four 2-mm intervening slices were discarded between five consecutive digital photographs of the coronal paranasal sinus CT scans

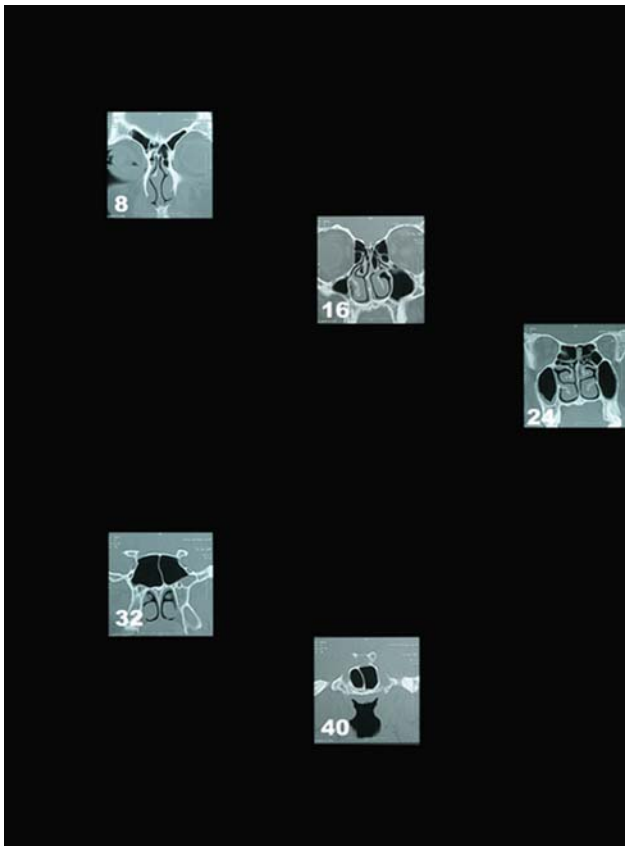

Fig. 6 To obtain a 16-mm interslice gap, seven 2-mm intervening slices were discarded between eight consecutive digital photographs of the coronal paranasal sinus CT scans

therapy and/or a high cost of treatment [17]. For this reason, the pre-existing definition of chronic rhinosinusitis was revised by the Task Force of the Sinus and Allergy Health Partnership in 2003 [5]. According to the new definition, an accurate diagnosis of chronic rhinosinusitis is not based solely on symptoms, and those symptoms should be associated with one of the signs of inflammation revealed by anterior rhinoscopy [5]. In addition, the Task Force stated that nasal endoscopy or paranasal sinus CT scan is valuable in confirming the diagnosis of rhinosinusitis [5].

Computed tomography is the imaging technique used most frequently to confirm a clinical diagnosis of rhinosinusitis. In addition, CT scans reveal the delicate anatomy of the nose and paranasal sinuses and provide a perfect "road map" for endoscopic sinus surgery. However, CT also has some disadvantages such as a high incidence of false-positive results, high cost, and radiation exposure for the patient. Sinus mucosal thickening revealed by CT is a nonspecific finding that may not represent inflammation and can be identified in asymptomatic individuals [18, 19]. If paranasal sinus CT findings are not confirmed by symptoms and signs, abnormal incidental findings may lead to the incorrect diagnosis of rhinosinusitis and unnecessary treatment. It should not be forgotten that a diagnosis of chronic rhinosinusitis should not be based only on the results of a paranasal sinus CT scan [5, 18, 20].

On the other hand, it is economically and clinically impossible to scan every patient who exhibits symptoms of rhinosinusitis [21]. The results of clinical examination are helpful in identifying patients who require radiologic evaluation to diagnose rhinosinusitis [22]. Initially, all patients in whom that disorder is suspected should undergo anterior rhinoscopy. If physical findings of inflammation are not detected during that procedure, nasal endoscopy should be performed [18, 23]. If the pathologic changes characteristic of rhinosinusitis cannot be identified with endoscopy, then a paranasal sinus CT scan is recommended [18, 23].

One of the most important limitations of paranasal sinus CT in confirming the diagnosis of rhinosinusitis is the cost. To decrease the cost, picture archiving and communication systems (PACS) may be used. By using this system, the acquisition, transport, viewing, reporting, and archiving of tomographic images can be made in a digital environment. In addition to decreased costs, PACS also provides additional advantages such as the immediate access of images, quick reporting, and synchronous access of images at differ-

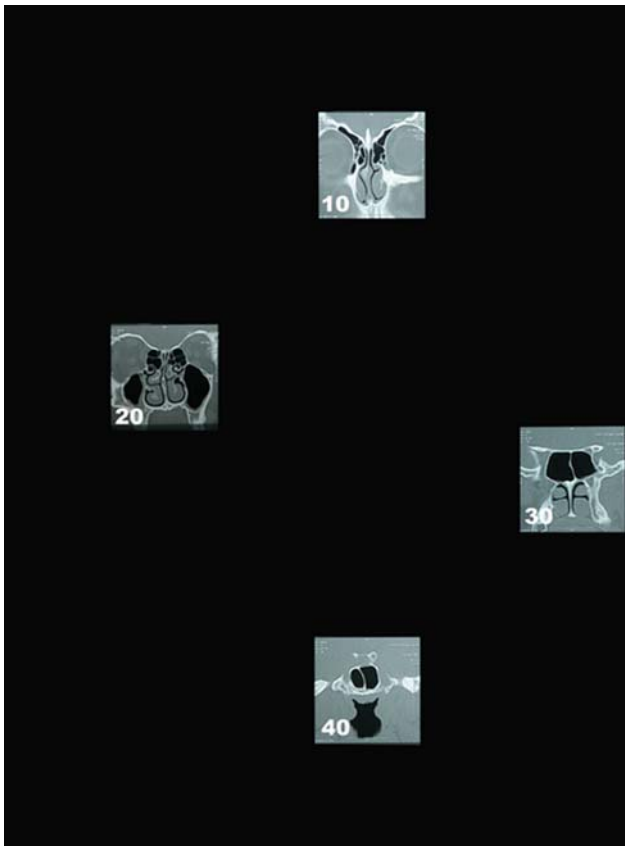

Fig. 7 To obtain a 20-mm interslice gap, nine 2-mm intervening slices were discarded between ten consecutive digital photographs of the coronal paranasal sinus CT scans

Table 1 Distribution of tomographic findings of various interslice gap compared with the findings of 2-mm coronal paranasal sinus CT scan

Interslice gap	2 mm	
	Normal	Mucosal thickening
4 mm		
Normal	3	1
Mucosal thickening	3	93
6 mm		
Normal	1	2
Mucosal thickening	5	92
8 mm		
Normal	3	6
Mucosal thickening	3	88
10 mm		
Normal	3	2
Mucosal thickening	3	92
16 mm		
Normal	4	8
Mucosal thickening	2	86
20 mm		
Normal	4	11
Mucosal thickening	2	83

Table 2 Sensitivity, specificity, and accuracy of 6 sets of CT scans of the coronal paranasal sinus in detecting mucosal thickening

Interslice gap (mm)	Sensitivity	Specificity	Accuracy	*P*
4	98.9	50	96	0.625
6	97.9	16.7	93	0.453
8	93.6	50	91	0.508
10	97.9	50	95	1
16	91.5	66.7	90	0.109
20	88.3	66.7	87	0.022*

* *P* values <0.05 were considered to indicate statistical significance

ent workstations [24]. However, PACS decrease only the cost of paranasal sinus CT scans; patients continue to be exposed to radiation at the same dose.

Several strategies have been suggested for decreasing this exposure (as well as the cost of the procedure); for example, lowering the milliampere setting of the scan or decreasing the number of slices obtained [25–32]. Although lowering the milliampere setting is associated with increased noise and more artifacts, the image quality is not negatively affected to a great extent [28, 31]. Decreasing milliampere settings to 60 or 65 mA or even to 40 mA does not result in a decrease in image quality [27, 28, 33].

The other method of decreasing the cost of, and amount of radiation exposure from, CT scanning is to decrease the number of slices obtained. Screening CT protocols that have an interslice gap ranging from 5 mm to 1 cm are recommended in confirming the diagnosis of rhinosinusitis, which is the most frequent condition for which examination via a paranasal sinus CT is requested [14–16]. Awaida et al. [25] and Goodman et al. [26] developed a similar four-slice screening protocol with a sensitivity of 81.3 and 93.3%, respectively, and a specificity of 89.5 and 89.3%, respectively, for detecting mucosal thickenings in any sinus. In our previous study, a three-slice CT protocol with a sensitivity of 95.1% and a specificity of 92.6% was used to detect mucosal thickening [32]. Although protocols with few slices are helpful to confirm a diagnosis of rhinosinusitis, they are not sufficient to evaluate the delicate anatomy of the paranasal sinuses and are inappropriate for surgical planning [25, 26, 29, 30, 32]. Contiguous paranasal sinus CT scanning should be used in the preoperative planning of endoscopic sinus surgery. Usually, an interslice gap of 3–5 mm is recommended for a coronal paranasal sinus CT scan [2, 6–13]. An interslice gap of more than 5 mm is not recommended because it disturbs the surgical orientation [34].

It is obvious that increasing the interslice gap or lowering the slice number results in a low cost and less radiation

exposure for the patient. However, the accuracy of such a screening paranasal sinus CT scan, which is used in detecting mucosal thickening, should be high. Our objective was to determine which interslice gap or gaps are sufficient to confirm the diagnosis of rhinosinusitis. To that end, we calculated the sensitivity, specificity, and accuracy of six different sets of interslice gaps for each of 100 patients with suspected rhinosinusitis. We thus eliminated confounding variables, and the comparison of the six different interslice gaps was performed under identical conditions. All interslice gap settings (except 20 mm) had high sensitivity and accuracy values on overall examination. When compared with the interslices gap of 2 mm, only the 20-mm interslice gap was found to have less value in detecting sinus mucosal thickening (P = 0.022). When the mucosal thickening of any of the sinuses is of value in confirming the diagnosis of rhinosinusitis, an interslice gap of 4, 6, 8, 10, or 16 mm (but not 20 mm) may be used instead of a 2-mm interslice gap.

Conclusion

An interslice gap of up to 16 mm can be used as well as an interslice gap of 2 mm to detect mucosal thickening and confirm the clinical diagnosis of rhinosinusitis.

Conflict of interest statement None.

References

1. Lanza DC, Kennedy DW (1997) Adult rhinosinusitis defined. Otolaryngol Head Neck Surg 117(3 Pt 2):S1–S7. doi:10.1016/S0194-5998(97)70001-9
2. Stankiewicz JA, Chow JM (2002) A diagnostic dilemma for chronic rhinosinusitis: definition accuracy and validity. Am J Rhinol 16(4):199–202
3. Bonfils P, Halimi P, Le Bihan C, Nores JM, Avan P, Landais P (2005) Correlation between nasosinusal symptoms and topographic diagnosis in chronic rhinosinusitis. Ann Otol Rhinol Laryngol 114(1 Pt 1):74–83
4. Hwang PH, Irwin SB, Griest SE, Caro JE, Nesbit GM (2003) Radiologic correlates of symptom-based diagnostic criteria for chronic rhinosinusitis. Otolaryngol Head Neck Surg 128(4):489–496. doi:10.1016/S0194-5998(02)23295-7
5. Benninger MS, Ferguson BJ, Hadley JA, Hamilos DL, Jacobs M, Kennedy DW et al (2003) Adult chronic rhinosinusitis: definitions, diagnosis, epidemiology, and pathophysiology. Otolaryngol Head Neck Surg 129(3 Suppl):S1–S32. doi:10.1016/S0194-5998(03)01397-4
6. Zinreich SJ (1997) Rhinosinusitis: radiologic diagnosis. Otolaryngol Head Neck Surg 117(3 Pt 2):S27–S34. doi:10.1016/S0194-5998(97)70004-4
7. Zinreich SJ, Kennedy DW, Rosenbaum AE, Gayler BW, Kumar AJ, Stammberger H (1987) Paranasal sinuses: CT imaging requirements for endoscopic surgery. Radiology 163(3):769–775
8. Sataloff RT, Grossman CB, Gonzales C, Naheedy MH (1984) Computed tomography of the face and paranasal sinuses: Part I. Normal anatomy. Head Neck Surg 7(2):110–122. doi:10.1002/hed.2890070205
9. Zinreich SJ (1998) Functional anatomy and computed tomography imaging of the paranasal sinuses. Am J Med Sci 316(1):2–12. doi:10.1097/00000441-199807000-00002
10. Kennedy DW, Zinreich SJ, Rosenbaum AE, Johns ME (1985) Functional endoscopic sinus surgery: theory and diagnostic evaluation. Arch Otolaryngol 111(9):576–582
11. Yousem DM (1993) Imaging of sinonasal inflammatory disease. Radiology 188(2):303–314
12. Babbel RW, Harnsberger HR (1991) A contemporary look at the imaging issues of sinusitis: sinonasal anatomy, physiology, and computed tomography techniques. Semin Ultrasound CT MR 12(6):526–540
13. Babbel R, Harnsberger HR, Nelson B, Sonkens J, Hunt S (1991) Optimization of techniques in screening CT of the sinuses. AJNR Am J Neuroradiol 12(5):849–854
14. Stankiewicz JA (2003) Endoscopic and imaging techniques in the diagnosis of chronic rhinosinusitis. Curr Allergy Asthma Rep 3(6):519–522. doi:10.1007/s11882-003-0064-z
15. Chow JM, Mafee MF (1989) Radiologic assessment preoperative to endoscopic sinus surgery. Otolaryngol Clin North Am 22(4):691–701
16. White PS, Maclennan AC, Connolly AA, Crowther J, Bingham BJ (1996) Analysis of CT scanning referrals for chronic rhinosinusitis. J Laryngol Otol 110(7):641–643
17. Stankiewicz JA, Chow JM (2003) Cost analysis in the diagnosis of chronic rhinosinusitis. Am J Rhinol 17(3):139–142
18. Devaiah AK (2004) Adult chronic rhinosinusitis: diagnosis and dilemmas. Otolaryngol Clin North Am 37(2):243–252. doi:10.1016/S0030-6665(03)00151-8
19. Moonis G (2003) Imaging of sinonasal anatomy and inflammatory disorders. Crit Rev Comput Tomogr 44(4):187–228
20. Bhattacharyya T, Piccirillo J, Wippold FJ II (1997) Relationship between patient-based descriptions of sinusitis and paranasal sinus computed tomographic findings. Arch Otolaryngol Head Neck Surg 123(11):1189–1192
21. Evans KL (1994) Diagnosis and management of sinusitis. BMJ 309(6966):1415–1422
22. Engels EA, Terrin N, Barza M, Lau J (2000) Meta-analysis of diagnostic tests for acute sinusitis. J Clin Epidemiol 53(8):852–862. doi:10.1016/S0895-4356(00)00209-2
23. Lanza DC (2004) Diagnosis of chronic rhinosinusitis. Ann Otol Rhinol Laryngol Suppl 193:10–14
24. Watkins J (1999) A hospital-wide picture archiving and communication system (PACS): the views of users and providers of the radiology service at Hammersmith Hospital. Eur J Radiol 32(2):106–112. doi:10.1016/S0720-048X(99)00134-5
25. Awaida JP, Woods SE, Doerzbacher M, Gonzales Y, Miller TJ (2004) Four-cut sinus computed tomographic scanning in screening for sinus disease. South Med J 97(1):18–20. doi:10.1097/01.SMJ.0000087192.54366.96
26. Goodman GM, Martin DS, Klein J, Awwad E, Druce HM, Sharafuddin M (1995) Comparison of a screening coronal CT versus a contiguous coronal CT for the evaluation of patients with presumptive sinusitis. Ann Allergy Asthma Immunol 74(2):178–182
27. Kearney SE, Jones P, Meakin K, Garvey CJ (1997) CT scanning of the paranasal sinuses - the effect of reducing mAs. Br J Radiol 70(838):1071–1074
28. Marmolya G, Wiesen EJ, Yagan R, Haria CD, Shah AC (1991) Paranasal sinuses: low-dose CT. Radiology 181(3):689–691
29. White PS, Robinson JM, Stewart IA, Doyle T (1990) Computerized tomography mini-series: an alternative to standard paranasal sinus radiographs. Aust N Z J Surg 60(1):25–29. doi:10.1111/j.1445-2197.1990.tb07348.x

30. Witte RJ, Heurter JV, Orton DF, Hahn FJ (1996) Limited axial CT of the paranasal sinuses in screening for sinusitis. AJR Am J Roentgenol 167(5):1313–1315
31. Hagtvedt T, Aalokken TM, Notthellen J, Kolbenstvedt A (2003) A new low-dose CT examination compared with standard-dose CT in the diagnosis of acute sinusitis. Eur Radiol 13(5):976–980
32. Cagici CA, Cakmak O, Hurcan C, Tercan F (2005) Three-slice computerized tomography for the diagnosis and follow-up of rhinosinusitis. Eur Arch Otorhinolaryngol 262(9):744–750. doi:10.1007/s00405-004-0896-8
33. Duvoisin B, Landry M, Chapuis L, Krayenbuhl M, Schnyder P (1991) Low-dose CT and inflammatory disease of the paranasal sinuses. Neuroradiology 33(5):403–406. doi:10.1007/BF00598612
34. Melhem ER, Oliverio PJ, Benson ML, Leopold DA, Zinreich SJ (1996) Optimal CT evaluation for functional endoscopic sinus surgery. AJNR Am J Neuroradiol 17(1):181–188