ACR Appropriateness Criteria Sinonasal Disease

Rebecca S. Cornelius, MD[a], Jamie Martin, MD[b], Franz J. Wippold II, MD[c], Ashley H. Aiken, MD[d], Edgardo J. Angtuaco, MD[e], Kevin L. Berger, MD[f], Douglas C. Brown, MD[g], Patricia C. Davis, MD[h], Charles T. McConnell Jr, MD[i], Laszlo L. Mechtler, MD[j], Brian Nussenbaum, MD[k], Christopher J. Roth, MD[l], David J. Seidenwurm, MD[m]

Sinonasal imaging is performed in 2 major clinical scenarios: inflammatory rhinosinusitis or suspected mass lesion. Rhinosinusitis affects more than 16% of the US population annually. It poses an immense economic burden, accounting for more than 26 million outpatient visits annually and costing more than $4.3 billion annually in direct medical expenses. Most cases of uncomplicated acute and subacute rhinosinusitis are diagnosed clinically and should not require any imaging procedure. CT of the sinuses without contrast is the imaging method of choice in patients with recurrent acute sinusitis or chronic sinusitis. Sinusitis cannot be diagnosed on the basis of imaging findings alone. CT scan findings should be interpreted in conjunction with clinical and endoscopic findings. MRI is currently used for evaluation of sinus disease as a complementary study in cases of aggressive sinus infection with ocular/intracranial complications, potential invasive fungal sinusitis in immunocompromised patients or in the evaluation of a sinonasal mass.

The ACR Appropriateness Criteria are evidence-based guidelines for specific clinical conditions that are reviewed every 2 years by a multidisciplinary expert panel. The guideline development and review include an extensive analysis of current medical literature from peer-reviewed journals and the application of a well-established consensus methodology (modified Delphi) to rate the appropriateness of imaging and treatment procedures by the panel. In those instances where evidence is lacking or not definitive, expert opinion may be used to recommend imaging or treatment.

Key Words: Appropriateness criteria, sinus CT, acute rhinosinusitis, chronic rhinosinusitis, fungal sinusitis

J Am Coll Radiol 2013;10:241-246. Copyright © 2013 American College of Radiology

SUMMARY OF LITERATURE REVIEW

Introduction/Background

Sinonasal imaging is performed in 2 major clinical scenarios: inflammatory rhinosinusitis or a suspected mass lesion.

Rhinosinusitis is defined as inflammation of the nasal cavity and adjacent paranasal sinuses. Acute sinusitis refers to symptom duration less than 4 weeks; subacute, 4 to 12 weeks; and chronic, more than 12 weeks. Complicated sinusitis refers to symptoms suggesting spread of disease into adjacent structures, including orbital or intracranial complications [1].

Rhinosinusitis is one of the most commonly diagnosed diseases in the United States and appears to affect more than 16% of the US population annually [2]. It poses an immense economic burden, accounting for

[a]University of Cincinnati, Cincinnati, Ohio.
[b]Radiology Associates of Southeast Ohio, Zanesville, Ohio.
[c]Mallinckrodt Institute of Radiology, Saint Louis, Missouri.
[d]Emory Healthcare, Atlanta, Georgia.
[e]University of Arkansas for Medical Sciences, Little Rock, Arkansas.
[f]Chesapeake Medical Imaging, Annapolis, Maryland.
[g]Hampton Roads Radiology Associates, Norfolk, Virginia.
[h]Northwest Radiology Consultants, Atlanta, Georgia.
[i]Good Samaritan Hospital, Cincinnati, Ohio.
[j]Dent Neurologic Institute, Amherst, New York, American Academy of Neurology.
[k]Washington University School of Medicine, Saint Louis, Missouri, American Academy of Otolaryngology-Head and Neck Surgery.
[l]Duke University Medical Center, Durham, North Carolina.
[m]Radiological Associates of Sacramento, Sacramento, California.

Corresponding author and reprints: Rebecca S. Cornelius, MD, American College of Radiology, 1891 Preston White Drive, Reston, VA 20191; e-mail: beccacornel@aol.com

The ACR seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply individual or society endorsement of the final document.

Dr. Seidenwurm reported the following roles: ACR accreditation reviewer, medical legal consulting, and consultant, OSF Pharmaceuticals.

0091-2182/13/$36.00 • http://dx.doi.org/10.1016/j.jacr.2013.01.001

Variant 1. Acute (<4 weeks) or subacute (4-12 weeks) uncomplicated rhinosinusitis

Radiologic Procedure	Rating	Comments	RRL*
CT paranasal sinuses without contrast	5	Most episodes are managed without imaging, as this is primarily a clinical diagnosis. Imaging may be indicated if acute frontal or sphenoid sinusitis is suspected, if there are atypical symptoms, or if the diagnosis is uncertain.	☢☢
MRI head and paranasal sinuses without contrast	4	May be useful as part of a general workup for headache.	O
MRI head and paranasal sinuses without and with contrast	2	May be useful as part of a general workup for headache.	O
CT paranasal sinuses with contrast	2		☢☢
CT paranasal sinuses without and with contrast	1		☢☢☢
X-ray paranasal sinuses	1		☢

Note: Rating Scale: 1,2,3 = usually not appropriate; 4,5,6 = may be appropriate; 7,8,9 = usually appropriate.
*Relative Radiation Level.

more than 26 million outpatient visits annually and costing more than $4.3 billion annually in direct medical expenses [3,4]. The indirect costs of rhinosinusitis also appear to be staggering, with the number of annual work-loss days estimated at 12.5 million [5-7]. Studies performed in the 1990s found there were 73 million restricted-activity days related to chronic sinusitis over a 2-year period [3,8,9].

The diagnosis of rhinosinusitis is based on clinical grounds (see Variant 1). In 1997, the Task Force of Rhinosinusitis developed major and minor symptomatic criteria for diagnosing rhinosinusitis. Major criteria include nasal drainage, nasal congestion, facial pain or pressure, postnasal drip, and olfactory dysfunction. Minor criteria include fever, cough, fatigue, dental pain, and ear fullness or pressure. Clinical judgment, combined with history and physical examination, is usually sufficient to diagnose sinusitis in most cases of uncomplicated acute and subacute rhinosinusitis. Imaging studies should be reserved for patients who develop recurrent acute sinusitis, complicated sinusitis, or chronic sinusitis with atypical symptoms, or for defining sinus anatomy before surgery [1,10-18]. Clinical evaluation combined with nasal endoscopy may obviate the need for CT imaging in some cases of chronic rhinosinusitis [19] (see Variant 2).

Imaging Modalities

CT is the imaging method of choice for the paranasal sinuses [20]. Coronal CT imaging gives the best overall anatomic detail of the paranasal sinuses and can be achieved either with prone direct coronal imaging or can be reformatted from thin-slice axial images. Contrast enhancement is not generally needed for routine sinus imaging. Sinus radiographs are inaccurate in a high percentage of patients and have been supplanted by CT imaging [21].

In recent years, the use of cone-beam CT has expanded from dental applications to in-office use for sinonasal evaluation. This technique offers advantages of patient convenience and likely some radiation dose reduction, though the true dose reduction in clinical use may be variable. The potential for overuse when scanning is available as an in-office procedure is significant. Strict guidelines for appropriate use should be established by practices offering this technology to avoid unnecessary scans [22-24].

Variant 2. Recurrent acute or chronic rhinosinusitis (possible surgical candidate)

Radiologic Procedure	Rating	Comments	RRL*
CT paranasal sinuses without contrast	9	Consider using as a surgical planning protocol.	☢☢
CT paranasal sinuses with contrast	4		☢☢
CT paranasal sinuses without and with contrast	3		☢☢☢
MRI head and paranasal sinuses without and with contrast	3		O
MRI head and paranasal sinuses without contrast	2		O
X-ray paranasal sinuses	1	May be indicated for planning frontal sinus obliteration.	☢
SPECT paranasal sinuses	1		☢☢☢

Note: Rating Scale: 1,2,3 = usually not appropriate; 4,5,6 = may be appropriate; 7,8,9 = usually appropriate.
*Relative Radiation Level.

Variant 3. Acute or subacute rhinosinusitis with associated orbital and/or intracranial complications with ocular and/or neurologic deficit

Radiologic Procedure	Rating	Comments	RRL*
CT paranasal sinuses and orbits without contrast	9	MRI and CT are complementary examinations. Brain imaging is essential if CNS invasion is a concern.	☢☢
MRI head and paranasal sinuses without and with contrast	9	MRI and CT are complementary examinations. See statement regarding contrast in text under "Anticipated Exceptions."	O
CT paranasal sinuses and orbits with contrast	8	If this is the only study that can be obtained, it would be appropriate. Contrast and brain imaging are essential if CNS invasion is a concern.	☢☢
MRI head and paranasal sinuses without contrast	7	If patient is unable to tolerate gadolinium.	O
CT paranasal sinuses and orbits without and with contrast	3	Contrast and brain imaging are essential if CNS invasion is a concern.	☢☢☢
X-ray paranasal sinuses	1		☢

Note: Rating Scale: 1,2,3 = usually not appropriate; 4,5,6 = may be appropriate; 7,8,9 = usually appropriate.
*Relative Radiation Level.

Single-photon-emission CT (SPECT) may have a limited role in the evaluation of chronic rhinosinusitis. One study has shown that positive SPECT in patients with chronic rhinosinusitis is correlated with poor subjective response to medical treatment [25].

MRI is currently used for evaluation of sinus disease as a complementary study in cases of aggressive sinus infection with ocular and/or intracranial complications or in the evaluation of a sinonasal mass (see Variant 3). Because of its cost, longer imaging time, and lack of bone detail, MRI has not been considered the imaging method of choice for routine sinus imaging. Recent public health concerns regarding the dramatic and ever-increasing usage of CT imaging and emphasis on reducing medical radiation exposure may lead to consideration of alternative imaging techniques. One study suggests that MRI-based Lund-Mackay scores did not show a statistically significant difference compared to CT-based scores in the same patients [26].

Sinusitis cannot be diagnosed on the basis of imaging findings alone. Findings on CT scans should be interpreted in conjunction with clinical and endoscopic findings [27-34]. From 3% to 40% of asymptomatic adults have abnormalities on sinus CT scans, as do more than 80% of those with minor upper respiratory tract infections [7,35-37].

Fungal Sinusitis

Fungal sinusitis can be seen in both immunocompetent and immunocompromised patients. Immunocompetent patients with chronic sinusitis may develop a superimposed fungal colonization. This is a noninvasive form of fungal disease and may manifest as either a fungus ball (mycetoma) or allergic fungal sinusitis. Invasive fungal sinusitis is a rapidly progressive disease seen in immunosuppressed patients and poorly controlled diabetics. In this patient population, a high index of suspicion should be maintained. Invasive fungal sinusitis has a very high morbidity and mortality rate and requires prompt diagnosis and treatment. In this patient population, both CT

Variant 4. Acute or subacute rhinosinusitis in immunodeficient patient

Radiologic Procedure	Rating	Comments	RRL*
CT paranasal sinuses without contrast	7	These patients are at high risk for invasive fungal sinusitis, thus lowering the threshold for imaging.	☢☢
MRI head and paranasal sinuses without contrast	6		O
MRI head and paranasal sinuses without and with contrast	6	See statement regarding contrast in text under "Anticipated Exceptions."	O
CT paranasal sinuses with contrast	5	Contrast and brain imaging are essential if CNS invasion a concern.	☢☢
CT paranasal sinuses without and with contrast	3		☢☢☢
X-ray paranasal sinuses	1		☢

Note: Rating Scale: 1,2,3 = usually not appropriate; 4,5,6 = may be appropriate; 7,8,9 = usually appropriate.
*Relative Radiation Level.

Variant 5. Sinonasal polyposis (if unilateral see variant 6)

Radiologic Procedure	Rating	Comments	RRL*
CT paranasal sinuses without contrast	9		☢☢
MRI head and paranasal sinuses without and with contrast	4	If unilateral disease, see variant 6. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI head and paranasal sinuses without contrast	4		O
CT paranasal sinuses with contrast	4		☢☢
CT paranasal sinuses without and with contrast	3		☢☢☢
X-ray paranasal sinuses	1		☢

Note: Rating Scale: 1,2,3 = usually not appropriate; 4,5,6 = may be appropriate; 7,8,9 = usually appropriate.
*Relative Radiation Level.

and MRI of the sinuses, brain, and orbits may be needed to fully define the extent of orbital or intracranial extension of disease. CT with contrast may be used to help define orbital and intracranial complications, though more accurate evaluation will be obtained with MRI without and with contrast [38-40] (see Variant 4).

Sinonasal Polyposis

In patients with known or suspected sinonasal polyposis (including cystic fibrosis patients), sinus CT without contrast is the study of choice. Rarely, in selected cases, evaluation with MRI or contrast-enhanced sinus CT may be needed to help differentiate polypoid mucosal hypertrophy from superimposed sinus fluid and also help to exclude a true underlying soft-tissue mass causing sinus obstruction (see Variant 5).

Suspected Sinonasal Mass

In patients with a suspected sinonasal mass seen on sinus CT or with persistent symptoms of pain, nasal obstruction, or epistaxis, complete evaluation of the extent of disease usually requires both sinus CT and MRI evaluation. CT imaging will best define the pattern of bone erosion and/or destruction as well as any formation of cartilaginous or bone matrix. MRI without and with contrast will best differentiate soft-tissue mass from postobstructive secretions and will delineate evidence of orbital, skull base, or intracranial extension of tumor [38,39,41]. In some instances, craniofacial catheter angiography may be indicated for preoperative planning, for preoperative embolization of a vascular mass, or to treat severe epistaxis [38,42-44] (see Variant 6).

Image-guided functional endoscopic sinus surgery (FESS) has become widely used. Preoperative CT scanning techniques will be vendor-specific depending on the image-guided system being used.

SUMMARY

- Most cases of uncomplicated acute and subacute rhinosinusitis are diagnosed clinically and should not require any imaging procedure.
- CT of the sinuses without contrast is the imaging method of choice in patients with recurrent acute sinusitis or chronic sinusitis, or to define sinus anatomy before surgery.

Variant 6. Sinonasal obstruction, suspected mass lesion

Radiologic Procedure	Rating	Comments	RRL*
MRI head and paranasal sinuses without and with contrast	9	MRI and CT are complementary examinations. See statement regarding contrast in text under "Anticipated Exceptions."	O
CT paranasal sinuses without contrast	8	MRI and CT are complementary examinations. Both are frequently needed.	☢☢
CT paranasal sinuses with contrast	6		☢☢
CT paranasal sinuses without and with contrast	6		☢☢☢
MRI head and paranasal sinuses without contrast	5	If patient is unable to tolerate gadolinium.	O
Arteriography craniofacial	4	Appropriate in selected cases (eg, vascular involvement, vascular lesion).	☢☢
X-ray paranasal sinuses	1		☢

Note: Rating Scale: 1,2,3 = usually not appropriate; 4,5,6 = may be appropriate; 7,8,9 = usually appropriate.
*Relative Radiation Level.

Table 1. Relative radiation level designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢ ☢	0.1-1 mSv	0.03-0.3 mSv
☢ ☢ ☢	1-10 mSv	0.3-3 mSv
☢ ☢ ☢ ☢	10-30 mSv	3-10 mSv
☢ ☢ ☢ ☢ ☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

- Immunocompromised patients are at high risk for invasive fungal sinusitis. A high index of suspicion for complicated sinusitis should be maintained.
- In patients with suspected sinonasal mass or suspected orbital and/or intracranial complication of sinusitis, MRI and CT are complementary studies.

ANTICIPATED EXCEPTIONS

Nephrogenic systemic fibrosis is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (ie, < 30 mL/min/1.73m^2), and almost never in other patients. There is growing literature regarding nephrogenic systemic fibrosis. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk. It is also advisable to limit the type and amount in patients with estimated glomerular filtration rate rates < 30 mL/min/1.73m^2. For more information, please see the ACR *Manual on Contrast Media* [45].

RELATIVE RADIATION LEVEL INFORMATION

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (Table 1). Additional information regarding radiation dose assessment for imaging examinations can be found in the "ACR Appropriateness Criteria Radiation Dose Assessment Introduction" document [46].

For additional information on ACR Appropriateness Criteria, refer to www.acr.org/ac.

REFERENCES

1. Lanza DC, Kennedy DW. Adult rhinosinusitis defined. Otolaryngol Head Neck Surg 1997;117:S1-7.
2. Fagnan LJ. Acute sinusitis: a cost-effective approach to diagnosis and treatment. Am Fam Physician 1998;58:1795-802,805-6.
3. Anzai Y, Weymuller EA, Jr., Yueh B, Maronian N, Jarvik JG. The impact of sinus computed tomography on treatment decisions for chronic sinusitis. Arch Otolaryngol Head Neck Surg 2004;130:423-8.
4. Ray NF, Baraniuk JN, Thamer M, et al. Healthcare expenditures for sinusitis in 1996: contributions of asthma, rhinitis, and other airway disorders. J Allergy Clin Immunol 1999;103:408-14.
5. Batra PS. Radiologic imaging in rhinosinusitis. Cleve Clin J Med 2004; 71:886-8.
6. Murphy MP, Fishman P, Short SO, Sullivan SD, Yueh B, Weymuller EA, Jr. Health care utilization and cost among adults with chronic rhinosinusitis enrolled in a health maintenance organization. Otolaryngol Head Neck Surg 2002;127:367-76.
7. Okuyemi KS, Tsue TT. Radiologic imaging in the management of sinusitis. Am Fam Physician 2002;66:1882-6.
8. Anand VK. Epidemiology and economic impact of rhinosinusitis. Ann Otol Rhinol Laryngol Suppl 2004;193:3-5.
9. Anzai Y, Yueh B. Imaging evaluation of sinusitis: diagnostic performance and impact on health outcome. Neuroimaging Clin N Am 2003;13:251-63, xi.
10. Arango P, Kountakis SE. Significance of computed tomography pathology in chronic rhinosinusitis. Laryngoscope 2001;111:1779-82.
11. Bhattacharyya N. Test-retest reliability of computed tomography in the assessment of chronic rhinosinusitis. Laryngoscope 1999;109:1055-8.
12. Bhattacharyya N. Clinical and symptom criteria for the accurate diagnosis of chronic rhinosinusitis. Laryngoscope 2006;116:1-22.
13. Bhattacharyya N, Fried MP. The accuracy of computed tomography in the diagnosis of chronic rhinosinusitis. Laryngoscope 2003;113:125-9.
14. Stewart MG, Donovan DT, Parke RB, Jr., Bautista MH. Does the severity of sinus computed tomography findings predict outcome in chronic sinusitis? Otolaryngol Head Neck Surg 2000;123:81-4.
15. Stewart MG, Sicard MW, Piccirillo JF, Diaz-Marchan PJ. Severity staging in chronic sinusitis: are CT scan findings related to patient symptoms? Am J Rhinol 1999;13:161-7.
16. Tahamiler R, Canakcioglu S, Ogreden S, Acioglu E. The accuracy of symptom-based definition of chronic rhinosinusitis. Allergy 2007;62: 1029-32.
17. Zinreich SJ. Imaging for staging of rhinosinusitis. Ann Otol Rhinol Laryngol Suppl 2004;193:19-23.
18. Rosenfeld RM, Andes D, Bhattacharyya N, et al. Clinical practice guideline: adult sinusitis. Otolaryngol Head Neck Surg 2007;137:S1-31.
19. Bhattacharyya N, Lee LN. Evaluating the diagnosis of chronic rhinosinusitis based on clinical guidelines and endoscopy. Otolaryngol Head Neck Surg 2010;143:147-51.

20. Sonkens JW, Harnsberger HR, Blanch GM, Babbel RW, Hunt S. The impact of screening sinus CT on the planning of functional endoscopic sinus surgery. Otolaryngol Head Neck Surg 1991;105:802-13.

21. Aalokken TM, Hagtvedt T, Dalen I, Kolbenstvedt A. Conventional sinus radiography compared with CT in the diagnosis of acute sinusitis. Dentomaxillofac Radiol 2003;32:60-2.

22. Campbell PD, Jr., Zinreich SJ, Aygun N. Imaging of the paranasal sinuses and in-office CT. Otolaryngol Clin North Am 2009;42:753-64, vii.

23. Levin DC, Rao VM. Turf wars in radiology: the overutilization of imaging resulting from self-referral. J Am Coll Radiol 2004;1:169-72.

24. Levin DC, Rao VM, Parker L, Frangos AJ, Sunshine JH. Ownership or leasing of CT scanners by nonradiologist physicians: a rapidly growing trend that raises concern about self-referral. J Am Coll Radiol 2008;5:1206-9.

25. Saylam G, Gorgulu O, Korkmaz H, Dursun E, Ortapamuk H, Eryilmaz A. Do single-photon emission computerized tomography findings predict severity of chronic rhinosinusitis: a pilot study. Am J Rhinol Allergy 2009;23:172-6.

26. Lin HW, Bhattacharyya N. Diagnostic and staging accuracy of magnetic resonance imaging for the assessment of sinonasal disease. Am J Rhinol Allergy 2009;23:36-9.

27. Basu S, Georgalas C, Kumar BN, Desai S. Correlation between symptoms and radiological findings in patients with chronic rhinosinusitis: an evaluation study using the Sinonasal Assessment Questionnaire and Lund-Mackay grading system. Eur Arch Otorhinolaryngol 2005;262:751-4.

28. Bhattacharyya N. A comparison of symptom scores and radiographic staging systems in chronic rhinosinusitis. Am J Rhinol 2005;19:175-9.

29. Bhattacharyya T, Piccirillo J, Wippold FJ, 2nd.Relationship between patient-based descriptions of sinusitis and paranasal sinus computed tomographic findings. Arch Otolaryngol Head Neck Surg 1997;123:1189-92.

30. Cousin JN, Har-El G, Li J. Is there a correlation between radiographic and histologic findings in chronic sinusitis? J Otolaryngol 2000;29:170-3.

31. Devaiah AK. Adult chronic rhinosinusitis: diagnosis and dilemmas. Otolaryngol Clin North Am 2004;37:243-52, v.

32. Hwang PH, Irwin SB, Griest SE, Caro JE, Nesbit GM. Radiologic correlates of symptom-based diagnostic criteria for chronic rhinosinusitis. Otolaryngol Head Neck Surg 2003;128:489-96.

33. Kenny TJ, Duncavage J, Bracikowski J, Yildirim A, Murray JJ, Tanner SB. Prospective analysis of sinus symptoms and correlation with paranasal computed tomography scan. Otolaryngol Head Neck Surg 2001;125:40-3.

34. Wabnitz DA, Nair S, Wormald PJ. Correlation between preoperative symptom scores, quality-of-life questionnaires, and staging with computed tomography in patients with chronic rhinosinusitis. Am J Rhinol 2005;19:91-6.

35. Gwaltney JM, Jr., Phillips CD, Miller RD, Riker DK. Computed tomographic study of the common cold. N Engl J Med 1994;330:25-30.

36. Holbrook EH, Brown CL, Lyden ER, Leopold DA. Lack of significant correlation between rhinosinusitis symptoms and specific regions of sinus computer tomography scans. Am J Rhinol 2005;19:382-7.

37. Wittkopf ML, Beddow PA, Russell PT, Duncavage JA, Becker SS. Revisiting the interpretation of positive sinus CT findings: a radiological and symptom-based review. Otolaryngol Head Neck Surg 2009;140:306-11.

38. Momeni AK, Roberts CC, Chew FS. Imaging of chronic and exotic sinonasal disease: review. AJR 2007;189:S35-45;quiz S46-8.

39. Rao VM, el-Noueam KI. Sinonasal imaging. Anatomy and pathology. Radiol Clin North Am 1998;36:921-39, vi.

40. Younis RT, Anand VK, Davidson B. The role of computed tomography and magnetic resonance imaging in patients with sinusitis with complications. Laryngoscope 2002;112:224-9.

41. Yousem DM. Imaging of sinonasal inflammatory disease. Radiology 1993;188:303-14.

42. Lai V, Wong YC, Lam WY, Tsui WC, Luk SH. Inflammatory myofibroblastic tumor of the nasal cavity. AJNR Am J Neuroradiol 2007;28:135-7.

43. Palacios E, Restrepo S, Mastrogiovanni L, Lorusso GD, Rojas R. Sinonasal hemangiopericytomas: clinicopathologic and imaging findings. Ear Nose Throat J 2005;84:99-102.

44. Serrano E, Coste A, Percodani J, Herve S, Brugel L. Endoscopic sinus surgery for sinonasal haemangiopericytomas. J Laryngol Otol 2002;116:951-4.

45. American College of Radiology. *Manual on Contrast Media*. Available at: http://www.acr.org/Quality-Safety/Resources/Contrast-Manual. Accessed January 22, 2013.

46. American College of Radiology. ACR Appropriateness Criteria: radiation dose assessment introduction. Available at: http://www.acr.org/~/media/ACR/Documents/AppCriteria/RRLInformation.pdf. Accessed January 22, 2013.