Is there a role for up-to-date imaging in patients awaiting sinus surgery?

Lucy Huang[1,2], Isma Iqbal[1], Amy Pun[3], Jonathan Abbas[1], Soumya[1], Charmaine Woods[1,2], Joanne Rimmer[3,4], Eng Hooi Ooi[1,2]

[1]Department of Otorhinolaryngology Head and Neck Surgery, Flinders Medical Centre, South Australia, Australia; [2]College of Medicine and Public Health, Flinders University, South Australia, Australia; [3]Department of Otorhinolaryngology Head and Neck Surgery, Monash Health, Victoria, Australia; [4]Department of Surgery, Monash University, Victoria, Australia

Contributions: (I) Conception and design: L Huang, I Iqbal, J Abbas, EH Ooi; (II) Administrative support: J Rimmer, EH Ooi; (III) Provision of study materials or patients: J Rimmer, EH Ooi; (IV) Collection and assembly of data: L Huang, A Pun, Soumya, J Rimmer, EH Ooi; (V) Data analysis and interpretation: L Huang, C Woods; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Lucy Huang. Flinders Medical Centre, South Australia, Australia. Email: Lucy.huang.tw@gmail.com.

Background: Endoscopic sinus surgery (ESS) is indicated in chronic rhinosinusitis (CRS) if medical therapy fails. There is a long waiting time for patients to be seen in the outpatient clinic at Australian public hospitals. A repeat computed tomography (CT) sinus scan may be performed when the patient is seen in clinic before deciding on the extent of ESS if the previous CT scan was over a year ago. This study aims to determine if there is a difference in radiology scores between the two scans and whether the repeat CT changes the extent of the planned sinus surgery.

Methods: This is a retrospective multicentre Australian study. Patients who underwent two CT scans at least 12 months apart prior to ESS were included in the study. Two rhinologists reviewed the anonymized CT scans independently using the Lund-Mackay score (LMS) and decided the likely extent of surgery based on each CT scan. Wilcoxon signed-rank test was used to determine statistical significance.

Results: Fifty-six patients met the inclusion criteria. The median [interquartile range (IQR)] time difference between the two scans was 2.1 (1.5–3.7) years. There were no significant differences in LMS between the first and second CT scans (P=0.43) or the extent of planned ESS (P=0.95).

Conclusions: There is no significant evidence of LMS worsening while patients are on the waiting list to be seen in the ENT outpatient clinic. Many factors play a role in the extent of ESS, however, a repeat CT scan does not significantly affect the extent of ESS.

Keywords: Paranasal sinus; computed tomography (CT); Lund-Mackay score (LMS); endoscopic sinus surgery (ESS); chronic rhinosinusitis (CRS)

Received: 24 August 2019; Accepted: 15 February 2020; Published: 25 March 2020.

doi: 10.21037/ajo.2020.03.04

View this article at: http://dx.doi.org/10.21037/ajo.2020.03.04

Introduction

Chronic rhinosinusitis (CRS) is defined as inflammation of the paranasal sinuses and nasal mucosa lasting twelve weeks or longer (1). Rhinosinusitis is characterised by two or more symptoms of nasal congestion, nasal discharge, post-nasal drip, facial pain or pressure and reduction or loss of smell (1). The European Position Paper on Rhinosinusitis and Nasal Polyps and the Clinical Practice Guideline by the American Academy of Otolaryngology state that symptoms should be corroborated with either positive endoscopic findings or computed tomography (CT) changes to confirm the diagnosis (1,2). A CT scan is mandatory if the patient is to undergo surgery in order to guide the surgeon on disease extent and variations in anatomy. The Lund-Mackay scoring system (LMS) was first described in 1993 to determine

© Australian Journal of Otolaryngology. All rights reserved.

the radiological severity of sinus disease on CT scans (3). It is easy to perform with high inter-observer and intra-observer reliability and therefore has been widely accepted by clinicians without specialist radiological training (3,4).

CRS affects an estimated 1.9 million Australians (5). It markedly impacts on patients' quality of life and increases the economic burden on the public health system (6-8). In Australia, there is a public health system which is funded by the government while the private health system is funded by the patient and/or their health insurance. Due to the limitations in capacity, there is a significant waiting time for patients to be seen and treated in the public sector after being referred by their primary care physician (9,10). CRS is considered non-urgent and patients may wait up to 5 years to be seen. The patient may have an initial CT sinus scan from their primary care physician but this scan could have been done several years ago due to the waiting time to be seen in the public outpatient clinic. While there is no guidance in the literature whether the delay to surgical treatment may cause radiological progression of CRS, patients often complain of worsening symptoms. Therefore, some otolaryngology doctors may decide to repeat the CT sinus scan when they initially consult on the patient in the public outpatient clinic. It is unclear whether the repeat CT scan would demonstrate a radiological change in LMS and secondarily whether it changes the extent of planned ESS.

The aim of this study is to determine if there is a difference in the LMS between two CT scans performed at least a year apart while waiting to be seen by a specialist in the public health system. The secondary aim is to determine whether the repeat CT scan changes the planned extent of sinus surgery.

Methods

Ethical approval was granted by the Human Research Ethics Committee as a clinical audit (HREC 65.18). This is a retrospective multicentre study performed at Flinders Medical Centre in South Australia and Monash Health in Victoria. Patients who underwent ESS from January 2016 to November 2018 were identified from the hospital electronic operating database system.

Inclusion criteria were:

- ❖ Eighteen years old and above;
- ❖ Elective ESS for CRS;
- ❖ Patients with two CT scans of the paranasal sinuses prior to surgery which were at least 12 months apart.
- ❖ No ESS performed prior to the repeat CT scan.

The exclusion criteria were:

- ❖ Emergency surgery;
- ❖ Patients with known diseases that may affect the paranasal sinuses (e.g., granulomatosis with polyangiitis, sinonasal tumours, cystic fibrosis, facial trauma).

We chose an inclusion criterion of 12 months between CT scans for our study because an audit identified that patients with CRS regularly wait for more than 12 months before they are seen for consultation in the public outpatient clinic. All CT scans were de-identified and coded such that reviewers were blinded to the identities and the dates of the scans. Experienced rhinologists (J Rimmer and EH Ooi) of similar experience from each site scored the CT scans from their own centre. Each scan was scored using the LMS. The frontal, maxillary, anterior ethmoid, posterior ethmoid and sphenoid sinuses, for both left and right sides, were scored zero (no opacity), one (partial opacity) or two (complete opacity) per sinus. The ostiomeatal complex (OMC) is scored zero (patent) or two (obstructed). The maximum LMS for a CT scan is 24. Prior to reviewing the scans, the reviewers reached a consensus of scoring one for any mucosal opacification and scoring two only if the sinus was completely opacified. Five randomly selected scans, a total of ten, scored by both reviewers were used to determine inter-rater variability. For each CT scan, the reviewers also proposed the surgery they would perform, scoring one for each sinus they would operate on, and zero for those they would not operate on (with a maximum score of ten for the planned extent of sinus surgery). In general, the practice is to perform a mini-functional endoscopic sinus surgery (FESS) for maxillary and ethmoid disease or a full-house FESS if the sphenoid and frontal sinus was also involved in regards to extent of surgery performed. The patient demographics (age, gender), relevant medical history (smoking history, aspirin intolerance, asthma), patient reported symptoms using the Sino-Nasal Outcome Test (SNOT-22), post-operative follow up (complications, revision surgery) and reasons for repeating CT scans were also collected from case notes.

Statistical analysis

The data was not normally distributed therefore non-parametric statistical tests were employed (Related Samples Wilcoxon Signed Rank test). Spearman's rank order coefficient was used to determine the correlation of the LMS of the second scan with SNOT-22 and the extent of

© Australian Journal of Otolaryngology. All rights reserved.

the planned ESS. Cohen's kappa was used to determine the inter-rater variability between the two examiners for the LMS and the proposed operation related to each CT scan. The interpretation for kappa is as follows: <0 less than chance agreement; 0.01–0.20 slight agreement; 0.21–0.40 fair agreement; 0.41–0.60 moderate agreement; 0.61–0.80 substantial agreement; and 0.81–0.99 almost perfect agreement (11).

Results

There was a total of 56 patients in this study who met the inclusion criteria, 44 patients from South Australia and 12 patients from Victoria resulting in 112 CT sinus scans for analysis. The median [interquartile range (IQR)] age of the patients was 51.0 (39.0–64.8) years old. There were 36 males and 20 females. Relevant medical history is presented in *Table 1*.

Table 1 Medical history of participants

Medical history	Number	Percentage
Aspirin intolerance	1	1.8%
Active smokers	11	19.6%
Asthma	16	28.6%

The median (IQR) waiting time between the date of referral and the first outpatient clinic appointment was 2.7 (1.2–4.1) years. The median (IQR) time difference between the two scans was 2.1 (1.5–3.7) years. The median (IQR) time from first outpatient appointment to ESS was 0.8 (0.2–1.2) years.

The median (IQR) LMS of the first and second CT scans were 11 [6–14] and 12 [7–14] with no statistically significant difference between them (P=0.431), nor was there a significant difference in the extent of planned ESS based on the first and second scans (P=0.948). There was also no significant difference between each individual sinus when analysing the LMS or planned ESS between scans (*Table 2*). No changes to the anatomy were observed between the two scans in this study.

There was good correlation between the LMS for both CT scans and the extent of planned surgery (n=112, Spearman's ρ 0.769, P<0.0001). Pre-operative SNOT-22 was recorded in 21/56 patients. There was no correlation between the LMS of the second CT and the patients' perspective of their disease when using the SNOT-22 (n=21, Spearman's ρ −0.079, P=0.73).

One patient required revision ESS due to recurrent polyps obstructing their frontal sinus drainage pathway resulting in ongoing symptoms. The rate of surgical complication was 5.4% (3/56). Three complications were recorded in three patients: two complications (septal

Table 2 Lund-Mackay scores (LMS) or planned extent of endoscopic sinus surgery (ESS) scores for each sinus when compared between the first and second CT sinus scan

Anatomical area in the paranasal sinuses	Change in LMS, P value[a]	Change in planned extent of ESS, P value[a]
Right OMC	0.276	N/A
Left OMC	0.305	N/A
Right frontal	0.356	0.157
Left frontal	0.157	0.251
Right maxillary	0.132	0.763
Left maxillary	0.660	0.059
Right anterior ethmoid	0.796	0.782
Left anterior ethmoid	1.000	0.248
Right posterior ethmoid	0.197	0.796
Left posterior ethmoid	0.439	0.796
Right sphenoid	0.074	0.796
Left sphenoid	0.251	0.251

[a], by related samples Wilcoxon signed rank test. OMC, ostiomeatal complex; N/A, not applicable.

© Australian Journal of Otolaryngology. All rights reserved.

Table 3 Inter-rater variability of Lund-Mackay score using Cohen's kappa

Anatomical area in the paranasal sinuses	Cohen's kappa	Interpretation	Percentage agreement
Right OMC	0.348	Fair	70%
Left OMC	0.545	Moderate	80%
Right frontal	0.796	Substantial	90%
Left frontal	0.737	Substantial	90%
Right maxillary	1.000	Almost perfect	100%
Left maxillary	1.000	Almost perfect	100%
Right anterior ethmoid	N/A*	N/A*	90%
Left anterior ethmoid	0.111	Slight	80%
Right posterior ethmoid	0.630	Substantial	90%
Left posterior ethmoid	0.412	Moderate	80%
Right sphenoid	0.782	Substantial	90%
Left sphenoid	0.800	Almost perfect	90%

*, intra-rater variability was not significant enough to perform the statistical test because the right anterior ethmoid for comparison were unable to be calculated using Cohen's kappa as the scores for one reviewer was constant with no variation. OMC, ostiomeatal complex; N/A, not applicable.

Table 4 Inter-rater variability of the likelihood of operating on each sinus based on the CT scan using Cohen's kappa

Anatomical area in the paranasal sinuses	Cohen's kappa	Interpretation	Percentage agreement
Right frontal	0.310	Fair	60%
Left frontal	0.034	Slight	40%
Right maxillary	0.615	Substantial	90%
Left maxillary	0.615	Substantial	90%
Right anterior ethmoid	0.615	Substantial	90%
Left anterior ethmoid	N/A*	N/A*	80%
Right posterior ethmoid	0.737	Substantial	90%
Left posterior ethmoid	0.737	Substantial	90%
Right sphenoid	0.615	Substantial	80%
Left sphenoid	0.615	Substantial	80%

*, intra-rater variability was not significant enough to perform the statistical test because the left anterior ethmoid for planned ESS were unable to be calculated using Cohen's kappa as the scores for one reviewer was constant with no variation. N/A, not applicable.

haematoma and septal perforation) were related to the septoplasty performed in conjunction with ESS, and one patient had lateralisation of both middle turbinates with adhesions requiring revision ESS.

Inter-rater variability

The inter-rater variability of the LMS for each sinus is presented in *Table 3* and the likelihood of operation on each sinus is presented in *Table 4*. The right anterior ethmoid

© Australian Journal of Otolaryngology. All rights reserved.

for comparison of LMS and the left anterior ethmoid for planned ESS were unable to be calculated using Cohen's kappa as the scores for one reviewer were constant with no variation.

Discussion

CRS is a disease that greatly impacts on quality of life (12). Delay in accessing appropriate medical and surgical treatment can potentially increase long term health care costs along with loss of productivity (12,13). We hypothesised that lengthy delays in accessing specialist treatment in the public health system in Australia result in increased LMS and change in the extent of planned sinus surgery. This retrospective cohort study found no significant evidence of LMS worsening while patients are on the waiting list to be seen in the outpatient clinic. The subsequent decision about the extent of planned ESS was also unchanged, with the rhinologists in this study blinded to the dates of the scans. These results are similar to those of Fraczek *et al.* who also demonstrated no significant changes in mucosal thickening on CT scans over approximately 1 year (mean time interval of 338 days) (14). Despite a longer duration between CT scans in this study, of approximately 2.1 years (median time interval 782 days), there were still no significant changes in radiological scores.

Unnecessarily repeated scans of the paranasal sinuses not only incur additional costs to both patients and the health service but also expose patients to further radiation. Current low dose CT protocols reduces the radiation exposure for scans dedicated to the sinuses, but certain risks remain due to the cumulative effect on biological tissue (14). The most likely affected tissue is the lens, in which repeated exposure may result in radiation-induced cataract (15). The thyroid gland is the most radiosensitive organ in the body and may be affected by scattering even though it is not within the scanning field (15,16). With low dose protocols at 40 mA, the lens and thyroid are exposed to a mean radiation dose of 5.53 and 0.63 mGy respectively (17). A cumulative dose of 500 to 2,000 mGy is required to cause corneal opacities and over 5,000 mGy to cause cataract, while the risk of developing thyroid cancer increases after exposure to radiation dose of more than 50 to 100 mGy (17,18).

Benninger *et al.* demonstrated an almost linear increase in post-operative healthcare utilisation the longer a patient waited for ESS (13), suggesting that patients potentially have worse post-operative outcome and co-morbidities the longer they suffer from CRS. However, Benninger's study was retrospective in nature and based on medical and drug insurance claims, with no association to the actual severity of the disease (13). We did not find evidence of worsening of LMS in our patients experiencing symptoms for longer than 12 months which indirectly indicates that radiology alone is not sufficient to assess the severity or worsening of CRS. Hence repeating the CT sinus scan because patients have been waiting for many years to be seen in the public outpatient clinic is not supported by the findings of our study.

The SNOT-22 score has been recommended as the most suitable patient-reported outcome tool for CRS (19). As SNOT-22 was not completed when patients received their first CT scan during the initial presentation to their primary care physician, it is not possible to correlate the patients' symptoms with the first CT. In this study, there was no correlation between the LMS and the patient's perspective of their disease when using the SNOT-22 with the second CT scan. These findings are consistent with the literature regarding patients' symptomology and the LMS (4,20). Patient outcome measures are subjective and multiple factors play a role in the patient's perspective of their disease, resulting in poor correlation with objective measurements such as the LMS.

CT of the paranasal sinuses is an invaluable tool to not only assess the site and extent of sinus disease but also anatomical variations of the sinus and its relationship to the skull base and the orbit. The anatomy is unlikely to change over time unless complications related to sinus disease occur. When assessing the extent of sinus disease, the LMS has previously been shown to have high inter-rater and intra-rater reliability due to its simplicity (21). Inter-rater variability was assessed in the current study showing moderate to almost perfect agreement. However, the OMC and the left anterior ethmoid sinuses had lower inter-rater variability than expected despite the reviewers being of equivalent experience. This contradicts Julkunen *et al.* who demonstrated moderate inter-rater agreement for the OMC and anterior ethmoid sinuses (22). The inter-rater decision to operate on individual sinuses were generally consistent, except for the frontal sinuses. The decision to operate on the frontal sinuses was variable despite having substantial agreement on the LMS of the frontal sinuses. This may be a result of the recognised differences in the approach to frontal sinus surgery by different rhinologists (23). The limitations of the LMS is that it does not assess important considerations for ESS such as mucoceles or dehiscent lamina papyracea. The decision to operate on a particular

© Australian Journal of Otolaryngology. All rights reserved.

sinus is also unlikely to change regardless of whether the LMS is scored one or two for that sinus. However, in the literature the LMS is used as a surrogate for comparing radiological disease when assessing the outcomes of ESS (8,20). Therefore, we felt that it was important to use the LMS to evaluate the evidence of repeating CT sinus scans in an Australian public healthcare system.

There are recognised limitations to this study. The retrospective nature of the study means there is missing data when collecting information from case notes. Some patients in this study did not have a SNOT-22 recorded. Even though the two reviewers are both senior rhinologists of equivalent experience, there may still be differences in their management approaches. We attempted to assess the reasons for the decision to request a repeat CT scan but the reasons were often not recorded in the outpatient notes. The reason, when recorded, was due to the initial CT scan being performed years ago. It is conceivable that there could be other clinical reasons for ordering a repeat CT sinus scan such as a need for stealth guided sinus surgery, however, no patients were identified requiring this in our study. The hypothetical decision to operate on the individual sinus was based purely on the appearance of the individual sinus on the CT scan. This acts as a surrogate for the extent of treatment to allow statistical analysis. However, this does not fully reflect the decision making when performing ESS where consideration of other factors such as surrounding sinuses, drainage pathway and phenotype of CRS also play a role.

Conclusions

This Australian multi-institutional study demonstrates the LMS for CT sinus scans at least 1 year apart in patients undergoing ESS was not significantly different between scans. It is also important to be aware that other factors such as the pathophysiology of the underlying CRS that determines the extent of surgery. Therefore, we conclude from our study that the practice of routinely repeating a CT sinus scan is not recommended. CT scans should be repeated if the patient's symptoms and signs have significantly changed, surgery has been performed or suspected sinusitis-related complications have developed since the original scan.

Acknowledgments

We thank Dr. Nuwan Dharmawardana for help with the statistical analysis.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Ethical approval was granted by the Human Research Ethics Committee as a clinical audit (HREC 65.18).

References

1. Rosenfeld RM, Piccirillo JF, Chandrasekhar SS, et al. Clinical practice guideline (update): adult sinusitis. Otolaryngol Head Neck Surg 2015;152:S1-39.
2. Fokkens WJ, Lund VJ, Mullol J, et al. EPOS 2012: European position paper on rhinosinusitis and nasal polyps 2012. A summary for otorhinolaryngologists. Rhinology 2012;50:1-12.
3. Lund VJ, Mackay, IS. Staging in rhinosinusitis. Rhinology 1993;31:183-4.
4. Thwin M, Weitzel EK, McMains KC, et al. Validating the use of report-derived Lund-MacKay scores. Am J Rhinol Allergy 2009;23:33-5.
5. Statistics ABo. Australian Health Survey: First results Canberra. Available online: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55.0012011-12?OpenDocument
6. Yip J, Vescan AD, Witterick IJ, et al. The personal financial burden of chronic rhinosinusitis: A Canadian perspective. Am J Rhinol Allergy 2017;31:216-21.
7. Liu T, Cooper T, Earnshaw J, et al. Disease burden and productivity cost of chronic rhinosinusitis patients referred to a tertiary centre in Australia. Aust J Otolaryngol 2018;1:5.
8. Brooks SG, Trope M, Blasetti M, et al. Preoperative Lund-Mackay computed tomography score is associated with preoperative symptom severity and predicts quality-of-life outcome trajectories after sinus surgery. Int Forum Allergy Rhinol 2018;8:668-75.
9. Government of South Australia. SA Health Metropolitan Specialist Outpatient Clinics Median and Maximum Outpatient Waiting Time by Specialty and Hospital as at 31 July 2018. SA Health, 2018.

© Australian Journal of Otolaryngology. All rights reserved.

10. Stainkey LA, Seidl IA, Johnson AJ, et al. The challenge of long waiting lists: how we implemented a GP referral system for non-urgent specialist' appointments at an Australian public hospital. BMC Health Serv Res 2010;10:303.
11. Viera AJ, Garrett JM. Understanding interobserver agreement: the kappa statistic. Fam Med 2005;37:360-3.
12. Hopkins C, Rimmer J, Lund VJ. Does time to endoscopic sinus surgery impact outcomes in Chronic Rhinosinusitis? Prospective findings from the National Comparative Audit of Surgery for Nasal Polyposis and Chronic Rhinosinusitis. Rhinology 2015;53:10-7.
13. Benninger MS, Sindwani R, Holy CE, et al. Early versus delayed endoscopic sinus surgery in patients with chronic rhinosinusitis: impact on health care utilization. Otolaryngol Head Neck Surg 2015;152:546-52.
14. Frączek M, Masalski M, Guzinski M. Reliability of computed tomography scans in the diagnosis of chronic rhinosinusitis. Adv Clin Exp Med 2018;27:541-5.
15. Schulz B, Potente S, Zangos S, et al. Ultra-low dose dual-source high-pitch computed tomography of the paranasal sinus: diagnostic sensitivity and radiation dose. Acta Radiol 2012;53:435-40.
16. Zhang Y, Chen Y, Huang H, et al. Diagnostic radiography exposure increases the risk for thyroid microcarcinoma: a population-based case-control study. Eur J Cancer Prev 2015;24:439-46.
17. Lam S, Bux S, Kumar G, et al. A comparison between low-dose and standard-dose non-contrasted multidetector CT scanning of the paranasal sinuses. Biomed Imaging Interv J 2009;5:e13.
18. Iglesias ML, Schmidt A, Ghuzlan AA, et al. Radiation exposure and thyroid cancer: a review. Arch Endocrinol Metab 2017;61:180-7.
19. Morley AD, Sharp HR. A review of sinonasal outcome scoring systems - which is best? Clin Otolaryngol 2006;31:103-9.
20. Hopkins C, Browne JP, Slack R, et al. The Lund-Mackay staging system for chronic rhinosinusitis: how is it used and what does it predict? Otolaryngol Head Neck Surg 2007;137:555-61.
21. Oluwole M, Russell N, Tan L, et al. A comparison of computerized tomographic staging systems in chronic sinusitis. Clin Otolaryngol Allied Sci 1996;21:91-5.
22. Julkunen A, Terna E, Numminen J, et al. Inter-observer agreement of paranasal sinus computed tomography scans. Acta Otolaryngol 2017;137:611-7.
23. Soneru CP, Pinto JM. Patient and surgeon factors explain variation in the frequency of frontal sinus surgery. Laryngoscope 2018;128:2008-14.

doi: 10.21037/ajo.2020.03.04

Cite this article as: Huang L, Iqbal I, Pun A, Abbas J, Soumya, Woods C, Rimmer J, Ooi EH. Is there a role for up-to-date imaging in patients awaiting sinus surgery? Aust J Otolaryngol 2020;3:7.

© Australian Journal of Otolaryngology. All rights reserved.