RESEARCH ARTICLE

CT sinus and facial bones reporting by radiographers: findings of an accredited postgraduate programme

Paul Lockwood

Allied Health Department, Canterbury Christ Church University, Chatham, UK

Objectives: The aim of this study was to compare the observer performance of a cohort of radiographers in reporting CT sinus and facial bone investigations against a reference standard and alternative comparator of summary data from peer-reviewed literature.

Methods: The participants ($n = 6$) completed a 9-month part-time distance learning training programme prior to reporting an examination bank ($n = 25$ cases) from a retrospectively collected and anonymized digital imaging and communications in medicine archive of CT examinations with referral histories and clinical reports. A literature search was performed to identify an additional alternative comparison reference standard from studies reporting observer performance data in CT sinus and facial bone investigations of both trauma and sinus pathology (target conditions). The data analyses used to measure observer performance and determine differences between the cohort and the reference standards used statistical assessment models including accuracy, sensitivity, specificity, kappa (κ) and summary receiver-operating characteristic curves with estimated area under the curve (AUC).

Results: The cohort of radiographer sensitivity was 97.5%, specificity 93.6% and accuracy 95%, with $p < 0.000$, and a $\kappa = 0.9121$ score of agreement. The mean radiographer AUC was 0.9822. The summary reported data of the alternative literature reference standard comparator were AUC 0.9533 for sinus and 0.9374 for trauma.

Conclusions: The results suggest that this cohort of radiographers at the end of a period training in CT sinus and facial bones are able to clinically report comparably high standards. *Dentomaxillofacial Radiology* (2017) **46**, 20160440. doi: [10.1259/dmfr.20160440](https://doi.org/10.1259/dmfr.20160440)

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Introduction

The use of functional endoscopic sinus surgery is a common surgical procedure within the UK National Health Service (NHS) to preserve mucociliary function and expand drainage routes of the paranasal sinus when medical treatment has failed to resolve symptoms. It has been evidenced that reliance on clinical examination alone is unreliable for diagnosis.^{1,2} The inclusion of CT in the diagnostic pathway for sinus obstruction has been

shown to alter treatment and management decisions through anatomical mapping and diagnosis of pathological disease.¹⁻³

Likewise, in the initial diagnosis of maxillofacial trauma in the UK, CT is defined as the gold standard for cross-sectional imaging over MRI, owing to the ability to define bony anatomy (specifically infundibular complex, orbital lamina and cribriform lamina) and soft tissues.⁴⁻⁷ In maxillofacial injuries, CT has been shown to have a high diagnostic value in diagnosing traumatic injuries that initial clinical assessment may have missed owing to associated soft-tissue swelling of the surrounding anatomy,^{8,9} providing quick initial examination of osseous and soft-tissue injuries and further associated deep tissue injuries that may involve the facial and optic

Correspondence to: Mr Paul Lockwood. E-mail: paul.lockwood@canterbury.ac.uk

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nerves, muscles, glands, sinuses and cranial injuries.⁸ The evidence to further support the use of CT in the UK maxillofacial trauma pathway has included speed of examination,¹⁰ and the cost effectiveness to image and report the examination against its next nearest viable imaging modality. In the UK healthcare system, the economic costs of services are regulated by the Department of Health through NHS England (the executive non-departmental government body) to standardize all healthcare costs in the NHS. The 2016–17 tariff for a CT facial bone scan and reporting was £78 + £22, as opposed to an MRI scan and reporting of £124 + £22.¹¹ For patient health and safety reasons, and to reduce the potential risk of harm in imaging patients who are unconscious or sedated with no clinical history, CT is recommended as the first-line investigation in facial trauma as opposed to MRI, through the National Institute for Health and Care Excellence guidelines.¹²

The UK NHS service delivery evidence for implementing reporting radiographers (RRs) has been demonstrated by a recent UK Royal College of Radiologists (RCR) survey¹³ highlighting the current demand (29% rise in patient referrals for CT 2014–15)¹³ and capacity (radiologist workforce shortages) issues in UK radiology. The RCR estimated 230,000 patients in 2016 were waiting too long for diagnostic reports (over 31 days); 12,178 of these included CT and MRI scans.¹⁴ The evidence revealed 75% of English NHS trusts had a backlog of reporting.¹⁴ The estimated cost in the short term to reduce the backlog in 2015 was £88.2m, an increase of 57% from the previous year, through outsourcing to private telereporting companies.¹⁴ The RCR consider this cost to be equivalent to 1032 NHS consultant radiologist salaries.¹³ A recent NHS England report¹⁵ reviewed the effect of outsourcing had been unsuccessful not only owing to high costs, but clinicians had limited access to discuss complex cases with private providers/reporters leading to unnecessary repeat imaging, which further increased the reporting demand. NHS England¹⁵ highlighted the impact the workforce deficit had on diagnostic services as a significant bottleneck in the system. NHS England¹³ recommended the workforce restrictions need addressing through multiple national initiatives to resolve the low number of reporters. One long-term plan to achieve sustainable and economic solutions to the sector supported by the Department of Health,¹⁶ the Society and College of Radiographers and the RCR¹⁷ is the introduction of a skills mix of radiographer and radiologist teams working in reporting, funded in part by NHS England¹⁸ with a £15m 4-year initial investment to support early and fast reporting through a “National Diagnostics Capacity Fund”, with plans to finance amongst other areas an increase of radiographers and radiologists to improve patient outcomes.

The UK healthcare system definitions of the role of a consultant radiologist working in the NHS are set by the RCR. This clinical role is described as performing examinations and procedures in complex diagnostic and therapeutic imaging investigations and interventions,

and the reporting of medical images in trauma, disease and cancer.

The UK healthcare role of a diagnostic radiographer (commonly known globally as a radiologic technologist, or medical radiation technologist) has a very diverse career pathway and differs slightly from other foreign healthcare systems, although there is common scope of practice in the role globally, which includes imaging of the human anatomy, enforcement of radiation protection, justification of examinations and patient care. In the UK NHS, there are many subspecialties defined by the different imaging modalities, and each has role extension and advanced practice routes to consultancy level through master education. Within this study, the role of the RR is explored. Since 1994, the UK NHS has developed and implemented RRs to analyze, interpret and write the final examination report on a range of plain film, mammography, CT, MRI and nuclear medicine examinations. It is noted that other countries such as the Republic of Ireland, Finland, Norway, Australia, New Zealand and South Africa have also been developing and embedding RR roles for some years within their healthcare systems that is similar to the UK approach.

The postgraduate reporting course in CT sinus and facial bones in this study was accredited by the UK College of Radiographers in 2011. The course runs consecutively with the postgraduate certificate in CT head reporting, as a part-time work-based module (20 credits at Level 7) over a period of 9 months. The curriculum and teaching were developed jointly by consultant radiologists and RRs. The assessment criteria for the module include a written case study, a record of a minimum of 125 clinical reports and an objective structured examination (OSE).

The aim of this study was to investigate primarily whether a cohort of radiographer accuracy level in CT reporting of sinus and facial bone examinations is equal or equivalent in comparison with a radiologist performance level after a period of training (academic and clinical). This will be measured through the analysis of OSE results of the participants who have completed the programme ($n = 6$) against the defined OSE radiologist reference standard, accompanied by an exploration of the relationship between the Student's *t*-test performance against an alternative comparator (the published results from peer-reviewed literature in CT sinus and facial bone observer performance by radiologists).

Methods and materials

Ethics

This study has received ethics and governance approval agreed by the Faculty of Health and Wellbeing Research Ethics Committee.

Assessment of observer performance

The programme of study adhered to the postgraduate pathway of assessments for the clinical reporting

modules at our university, with a final assessment of competence through an OSE, consisting of 25 adult (>18 years) retrospective CT sinus and facial bone cases (index test) under controlled examination conditions,¹⁹ using low-level lighting and high-definition reporting monitors²⁰ that adhere to RCR reporting standards²¹ (42 cm, 1280 × 1084 screen resolution, >170 cd m⁻² luminance, ≥250:1 luminance contrast ratio). The CT studies were presented in digital imaging and communications in medicine format on KPACS software (Image Informations Systems Ltd, London, UK)²² to allow manipulation by the reader.²¹

Reference standard

A retrospectively collected and anonymized digital imaging and communications in medicine archive of CT sinus and facial bone examinations with referral histories (gender, age, clinical symptoms and previous medical history) and clinical reports was used in the construction of the OSE examination. Each case was independently reported by three consultant radiologists (each blinded to the original report, to minimize verification and work-up bias). The reference standard report for each examination was established through review and consensus of the three consultant radiologist²³ reports by the programme panel and external examiner (independent consultant radiologist). This process verified that an appropriate range of target conditions (and diagnostic thresholds) was incorporated to reflect the postgraduate-level knowledge and competence. The test banks contained negative cases (48%) and subtle and characteristic positive (single site and multisite) pathological cases (disease prevalence 52%).

Target conditions

In the paranasal sinus cases, positive target conditions included: the presence of soft-tissue lesions, polyps, retention cysts and mucocoeles; obstruction of the mucociliary drainage (ostium, ostiomeatal complex, infundibulum and middle meatus); and moderate mucosal changes (without fluid or opacification signs). Disease distribution of diffuse mucosal thickening was shown in multiple sinuses (unilateral or bilateral) such as rhinosinusitis (short-term symptomatic inflammation of the nasal cavity and paranasal sinus) and sinusitis inflammation of a single sinus cavity. In addition, secondary pressure effects of destruction, sclerosis or decalcification of the bony sinus walls from adjacent lesions and/or post-surgical interventions were included. Normal variants (to reduce spectrum bias) such as a deviated nasal septum, concha bullosa, paradoxical curvature of middle turbinates, uncinate bulla, onodi cells, hypoplastic frontal sinus, Haller cells, bulla ethmoidalis, posterior nasal septal air cells, *agger nasi* cells (not causing mechanical obstruction of frontal recess area) and aerated crista galli seen in isolation were deemed normal in this study.

For the facial bones, target cases included examples of orbital blowout fractures, complex midface injuries

with multiple osseous fractures (including Le Fort I, II and III), mandibular fractures, orbital trauma, associated soft-tissue emphysema, muscle, dental complications and herniated bone fragments. Normal variants for the facial bone cases included sutures, fissures, artefacts of partial-volume averaging and dental/ocular implants.

Index test

The scans were presented in standard CT protocols with a slice thickness of 3–5 mm coronal, axial and sagittal data sets. The volume data were reconstructed into adjustable bone (window width 2000 HU and window level 450 HU) and soft-tissue (window width 400 HU and level 50 HU) algorithms. The use of axial, coronal⁸ and sagittal^{24,25} CT reconstructions allowed the radiographers to review the triplanar (horizontal, sagittal and coronal) osseous struts⁸ for trauma, and the coronal views to approach the osteomeatal unit in paranasal sinus examinations.

Study population

The six RRs 1–6 were provided with the referral clinical symptoms, including gender, age (18–92 years) and the referral source (accident and emergency, general practitioner, in-patient and out-patient). The sampling method and inclusion criterion of the population in this observer performance test were randomly selected in both frequency and severity of target conditions. It was acknowledged that the patient history for CT sinus investigations could be deemed misleading, as age and gender distribution of cases has been evidenced to be inconsistent with pathological distribution. The correlation between symptoms of pain, tenderness, pressure, congestion, discharge, headache, dysosmia, anosmia/hyposmia and nasal blockage does not always associate to normal/abnormal findings.^{26–28}

Test bank instructions

The candidates were asked to decide whether the examination was normal or abnormal and provide a detailed report of findings (describing the exact anatomical location) in a free-text response, including the primary condition and any secondary mass effects. When identifying and classifying abnormal sinus appearances, details of the soft-tissue disease such as localized thickening of the wall, hypertrophic mucosa or focused opacification of the sinus (singular or in combination/expansion into adjoining sinus) were used. The presence of horizontal fluid levels within a sinus cavity, or if a lesion was seen, the size (in millimetre) and lesion/fluid characteristics (with associated bone erosion/destruction/extension in sinuses) was required.

The participants in this programme were not taught the Lund–Mackay system,^{29,30} although it has been widely adopted by others such as the American Academy of Otolaryngology as a system for pre-operative planning for chronic rhinosinusitis. Although it has scored better than other CT staging systems for chronic sinusitis (such as Jorgensen, May and Levine, Newman,³¹ Kennedy and Harvard,³² the Lund–Mackay system²⁸

Table 1 Summary reporting radiographer (RR) 1–6 observer performance results from the objective structured examination

RRs	Number of cases	TP	TN	FP	FN	Accuracy		Sensitivity		Specificity		Fisher's test p-value
						Accuracy	95% CI	Sensitivity	95% CI	Spec	95% CI	
RR 1	25	12	11	1	1	0.920	0.701–0.993	0.923	0.640–0.998	0.917	0.615–0.998	0.000
RR 2	25	13	11.5	0.5	0	0.980	0.778–0.980	1.000	0.753–1.000	0.958	0.672–1.000	0.000
RR 3	25	13.5	10	1	0.5	0.940	0.727–0.980	0.964	0.712–1.000	0.909	0.587–0.998	0.000
RR 4	25	11.5	12	1	0.5	0.940	0.725–0.980	0.958	0.672–1.000	0.923	0.640–0.998	0.000
RR 5	25	15	9	1	0	0.960	0.755–0.960	1.000	0.782–1.000	0.900	0.555–0.997	0.000
RR 6	25	13	12	0	0	1.000	0.805–1.000	1.000	0.753–1.000	1.000	0.735–1.000	0.000
Mean						0.950	0.733–0.982	0.975	0.913–0.997	0.936	0.851–0.980	0.000

CI, confidence interval; FN, false negative; FP, false positive; TN, true negative; TP, true positive.

has been shown not to be a significant predictor to influence patient outcomes^{1,32} and as such was not adopted as the candidates were also required to comment on the non-sinus facial anatomy as well.

Statistical analyses

Responses were classified as true positive (TP) and true negative (TN) for correct answers and false positive (FP) or false negative (FN) for incorrect answers, with the use of fractions (whole and partial) as described in a previous study.³³ Each examination paper was triple reviewed for concordance of marks, by two academics and an external examiner (consultant radiologist), to verify an accurate and fair marking process was followed inline with the established reference standard reports. Sensitivity, specificity and accuracy were calculated using standard measures of observer performance using a 2×2 contingency table,³⁴ with Fisher's exact test (displaying two-tailed *p*-value owing to the small sample size). Mean values were further estimated, and interobserver variation was observed using Cohen's kappa (κ) to correct for chance agreement,¹⁹ with Fleiss' kappa (κ) for multiple reader reliability agreement with 95% confidence intervals (CIs) and standard error. Further review using positive-predictive value and negative-predictive value was run to evaluate the performance of the reader influenced by the disease prevalence of the test. Likelihood ratios to assess the value of performing the test (not disease prevalence dependent). Diagnostic odds ratios as a global measure of RR 1–6 diagnostic accuracy (not disease prevalence dependant, but reliant on the spectrum of the target conditions used). Summary receiver-operating characteristic (ROC) curves were plotted with the area under the curve (AUC) estimated for the discriminative power

of the observers between the target conditions and negative cases.

Alternative comparator

A literature search was performed to identify an alternative comparison reference standard from studies reporting observer performance data in CT sinus and facial bone examinations (index test) for both trauma and sinus pathology (target conditions). The search used the Cochrane Central Register of Controlled Trials (CENTRAL) (the Cochrane Library October 2016, Issue 10) and the following databases from 1995 to 2016: MEDLINE, CINAHL and PubMed Central, while also conducting search through subject-specific electronic databases (ScienceDirect and Wiley Online) and Google Scholar. Further studies were identified for possible inclusion through review of reference lists from studies found in the initial search. Free-text words and Boolean operator search terms were included to identify specific and exact matches. Selection criteria included reviews of all cohort studies that used CT imaging as the index test for the target conditions. The patient population was defined from either a clinical examination or clinical diagnosis, and from a predefined radiological reference standard report in the study method. All observer groups included radiologists; two also included maxillofacial surgeons as readers. The published study data either defined the results in TP, FP, TN and FN or were derivable from data within the published study (such as sensitivity, specificity and accuracy). It was noted from the preliminary review of the published studies that no control group was included in the studies, but all had a defined reference standard to fulfil the criteria for acceptance. Found studies were reviewed for methodological quality against the Quality Assessment

Table 2 Summary reporting radiographer (RR) observer performance results from the objective structured examination

RRs	Number of cases	Cohen's kappa			Cohen's kappa			Fleiss' kappa		
		Unweighted κ	95% CI	SE	Linear Weighted κ	95% CI	SE	κ	95% CI	SE
RR 1	25	0.8397	0.6267–1.000	0.1087	0.8397	0.6266–1.000	0.1087	0.840	0.627–1.000	0.109
RR 2	25	0.9599	0.8498–1.000	0.0562	0.9599	0.850–1.000	0.0561	0.960	0.882–1.000	0.040
RR 3	25	0.8777	0.6879–1.000	0.0969	0.8777	0.6881–1.000	0.0967	0.878	0.744–1.000	0.068
RR 4	25	0.8800	0.6938–1.000	0.095	0.8800	0.694–1.000	0.0949	0.880	0.748–1.000	0.067
RR 5	25	0.9153	0.7526–1.000	0.083	0.9153	0.7532–1.000	0.0827	0.915	0.753–1.000	0.083
RR 6	25	1.000	1.000–1.000	0.000	1.000	1.000–1.000	0.000	1.000	1.000–1.000	0.000
Mean		0.8924	0.7131–1.000	0.0909	0.8998	0.7131–1.000	0.0909	0.9121	0.721–1.000	0.0611

CI, confidence interval; SE, standard error.

Figure 1 Summary receiver-operating characteristic curve of plots of the range of reporting radiographer 1–6 observer performance from the objective structured examination. AUC, area under the curve; FPR, false-positive rate; TPR, true-positive rate.

of Diagnostic Accuracy Studies (QUADAS-2) criteria.³⁵ There was minor variation in methods to display the results and therefore, where possible, reanalysis of the published data to conform to standard 2×2 contingency table. The analysis was performed using Cochrane Diagnostic Test Accuracy review software (Review Manager (RevMan) The Cochrane Collaboration, Copenhagen: Denmark)³⁶ and Meta-DiSc software (Unit of Clinical Biostatistics, Ramón y Cajal Hospital, Madrid: Spain).³⁷ Sensitivity and specificity were confirmed from the published data and displayed in a standardized interpretation model of forest plots as a graphical representation of the results of multiple trials and studies of the same intervention, with standardized interpretation model meta-analysis of results using pooled estimates, χ^2 with p -values (large sample distribution) and inconsistency (I^2) to identify any heterogeneity or consistency of results, with degrees of freedom. Summary ROC curve plots were used to assess and

illustrate the performance (discrimination threshold) through plotting the true-positive rate and false-positive rate of the range of multiple published results, and a summary AUC was calculated.

Results

Observer performance

The mean RR 1–6 sensitivity was 97.5% (95% CI 91.3–99.7), specificity 93.6% (95% CI 85.1–98) and accuracy 95% (95% CI 73.3–98.2), with significance of $p < 0.000$, as shown in Table 1. The mean RR 1–6 κ values for observer performance across all test banks combined (Cohen's $\kappa = 0.8924$, 95% CI 71.3–100, and Fleiss' $\kappa = 0.9121$, 95% CI 72.1–100) displayed a high κ score of agreement (Table 2). The mean RR 1–6 AUC was 0.9822 (plotted in Figure 1); the summary random effects model is displayed in Table 3.

Table 3 Summary random effects model of reporting radiographer (RR) 1–6 observer performance results from the objective structured examination

RRs	Number of cases	PPV		NPV		+LR		Negative likelihood ratio		DoR	
		PPV	95% CI	NPV	95% CI	+LR	95% CI	–LR	95% CI	DoR	95% CI
RR 1	25	0.923	0.712–0.993	0.917	0.688–0.993	11.077	1.685–72.816	0.084	0.013–0.556	132.00	7.336–2375.2
RR 2	25	0.963	0.776–0.963	1.000	0.780–1.000	12.536	1.902–82.629	0.039	0.003–0.591	324.00	9.555–10,545.3
RR 3	25	0.931	0.747–0.966	0.952	0.698–1.000	10.607	1.632–68.924	0.039	0.003–0.601	270.00	8.220–8868.8
RR 4	25	0.920	0.705–0.960	0.960	0.745–1.000	12.458	1.888–82.200	0.045	0.003–0.684	276.00	8.420–9047.0
RR 5	25	0.938	0.778–0.938	1.000	0.716–1.000	7.104	1.601–31.516	0.036	0.002–0.559	196.33	7.235–5328.1
RR 6	25	1.000	0.812–1.000	1.000	0.796–1.000	25.071	1.652–380.54	0.037	0.002–0.566	675.00	12.428–36,659.7
Mean		0.943	0.741–0.967	0.917	0.724–1.000	10.858	5.060–23.299	0.049	0.018–0.137	249.72	62.463–998.35

+LR, positive likelihood ratio; –LR, negative likelihood ratio; CI, confidence interval; DoR, diagnostic odds ratio; NPV, negative-predictive value; PPV, positive-predictive value.

Figure 2 Summary receiver-operating characteristic curve plots of the range of observer performance from published literature results in CT sinus studies. AUC, area under the curve; FPR, false-positive rate; TPR, true-positive rate.

Alternative comparator

For the literature review results, 10 studies were found ($n = 847$ sample size in total) for the CT sinus observer performance studies. 11 studies were identified (including $n = 2428$ sample size in total) for CT facial bones observer performance studies. The methodological quality of these studies was satisfactory for inclusion in this study. However, it is noted there is the potential for bias in certain studies related to the anatomical area of the

facial bones/sinus reviewed for focused target conditions. Results shown in ROC plots displayed in [Figure 2](#) a mean AUC of 0.9533 (sinus target conditions) and [Figure 3](#). Mean AUC 0.9374 (trauma target conditions) as an alternative comparator to the RR 1–6 AUC of 0.9822 ([Figure 1](#)). In [Figure 4](#), a forest plot demonstrates the alternative comparison sensitivity estimate of 90% (95% CI 87–92) and in [Figure 5](#), specificity of 78% (95% CI 73–82) for CT sinus observer performance,

Figure 3 Summary receiver-operating characteristic curve plots of the range of observer performance from published literature results in CT trauma studies. AUC, area under the curve; FPR, false-positive rate; TPR, true-positive rate.

Figure 4 Forest plot of observer sensitivity performance from published literature in CT sinus studies. CI, confidence interval.

with a similar sensitivity estimate of 87% (95% CI 85–89) in Figure 6 and specificity of 89% (95% CI 87–91) in Figure 7, for CT facial bones as an alternative comparator for the RR 1–6 results. The available literature evidence base when used in comparison with this cohort study suggests the students could diagnose target conditions with a high degree of confidence.

Discussion

The main findings of the RR 1–6 performance in CT sinus and facial bone reporting display a high degree of sensitivity, specificity and accuracy to the reference standard and current evidence base when assessed in an academic setting. Discordance of participant reports included minor FP error over the degree of mucosal thickening required to confirm chronic sinus conditions in a case referred for other conditions. This raises the issue of incidental findings in CT examinations of patients who are asymptomatic, giving FP results which previous studies have quoted various FP ranges of 2.1³⁸–5.2%.³⁹ Moreover, studies have questioned whether minor mucosal thickening of 4–5 mm has any clinical significance and may be related to normal variance or function of the

physiologic nasal cycle, and not correlated to allergic seasonal variance.⁴⁰ A further FP case involved a case of correct diagnosis of complete sinus opacification of the maxillary antrum, but queried whether there was an underlying lesion associated. Although, in this instance, there was no mixed signal density of the fluid or associated bony erosion or remodelling, it does raise the issue of correct identification of disease in a fluid-filled sinus cavity which may mask the underlying polyposis, lesion or a retention cyst.

Common satisfaction of search errors included FN errors of adjacent or additional conditions including deossification of ethmoid septa from bordering nasal polypi and small areas of further mucosal thickening in adjacent sinuses, and also an FN error of a small orbital floor herniation into the maxillary antrum in a case of complex facial trauma involving Le Fort III fractures.

Within facial injuries, Le Fort⁴¹ described and detailed facial trauma patterns to a standard that is still used today to classify the various possible traumatic bone fracture patterns to the structural pillars of the facial skeleton. Limitations of this system include the lack of associated soft-tissue injury identification, which may involve multiple anatomical areas with varying degrees of significance including orbital, sinus, nerve and

Figure 5 Forest plot of observer specificity performance from published literature in CT sinus studies. CI, confidence interval.

Figure 6 Forest plot of observer sensitivity performance from published literature in CT facial trauma studies. CI, confidence interval.

ligamentous involvement, in the diagnosis of unstable fractures primarily with anterior or lateral displacement which may involve further injuries such as sagittal fractures of the maxilla and palate.⁴² Although uncommon, they alter management owing to the significant instability and surgical management required to reduce and fixate the fragments. Indeed, any maxillofacial trauma has the potential for disfigurement, disability and facial nerve damage which can significantly alter patient treatment and management.

Gentry et al^{8,43} advise the use of axial and coronal CT reconstructions for facial trauma interpretation, which allows for specific search patterns of the facial struts. The horizontal, sagittal and anterior coronal struts (perpendicular to each other) allow compartmentalization of maxillofacial anatomy into oral, nasal, paranasal and orbital zones, enabling identification of osseous injuries and the structural attachments of facial and extraocular muscles and soft-tissue structures,⁴³ being particularly useful in structures such as the cribriform plate, hard palate, vomer, alveolar ridge and pterygopalatine fossa, which may give rise to FN reports if not reviewed thoroughly. The Gentry et al⁸ system is similar to various

other search patterns such as the Buttress system (four transverse and vertical buttresses) by Hopper et al⁴⁴ used for midface trauma, which has a correlation to more significant and life-threatening outcomes. Essentially, Gentry et al⁸ advise the coronal and axial planes as ideal for reviewing the facial structures. For this study, we also supplied sagittal plane reconstructions, as it supported diagnosis for herniation of structures, which allowed additional supplementary evidence of traumatic injuries to the orbital floor, malar strut, maxillary wall displacement, zygomaticomaxillary fractures and frontal sinus anatomy.^{24,25}

These evaluation findings have the potential for impact beyond academia, by embedding this defined scope of practice into radiographer advance practice roles. It is hoped future studies will determine the impact and outcomes of this research in conjunction with other RR work to reduce reporting backlogs, in comparison with nationally evidenced delays.¹⁴ In addition, it has been previously reported that radiographers are an economical and viable option in CT reporting,⁴⁵ and further review would be beneficial given the current NHS financial restraints. The impact of this study is to

Figure 7 Forest plot of observer specificity performance from published literature in CT facial trauma studies. CI, confidence interval.

supplement the growing evidence base of RRs outside of plain film reporting and into cross-sectional modalities^{33,46} to support service delivery and patient outcomes. It has been previously shown⁴⁷ that multimodality radiographer reporting can influence and benefit patient treatment and management to improve outcomes and care, which is a major factor in advancing the role development of radiographers in healthcare systems both nationally and internationally.

Limitations

A weakness of the literature review included the relatively small number of identified studies and sample size within each study (index tests and observers). It was noted that the literature on this subject is low, and therefore this will impact upon the results to be generalizable. Another significant weakness to identify is the heterogeneity identified in found literature, of which some focused on individual anatomical areas or specific target conditions. In addition, the author recognizes that this review of found literature reanalyzed the published data according to standard 2×2 contingency table to confirm its results. Although other models do exist, it was deemed beyond the scope of this review to discuss the statistical grounds for recommendations of different interpretation models.

Given the risk of bias and heterogeneity of found studies, an opinion could be made for not providing a review of these results to the found literature. However, it was believed that additional value was gained from it, despite limitations from the limited published research in this clinical area.

Conclusions

In this study, the overall aim was to investigate the performance of a group of radiographers at the end

of an accredited postgraduate programme in clinical reporting of CT sinus and facial bone investigations. The results displayed high levels of agreement when compared with the OSE reference standard. The evaluation and comparison of results with the published literature using standardized interpretation models suggest this cohort of participants can report selected CT investigations with satisfactory accuracy under examination conditions in an academic setting. The conclusions that can be reached from this preliminary study are limited by the method and sample size. However, the collaboration and integration of skills mix reporting for the benefit of patient outcomes have previously been shown in other reporting modalities, and it may also benefit CT sinus and facial bone reporting in the future. The impact of the data from this study could help increase the evidence base of advanced practice roles, although it is restricted currently to the defined roles available to UK radiographers. This may not be at present be globally generalizable to other healthcare systems; it is noted other countries are developing and implementing RR roles to benefit service provision through healthcare improvement initiatives.

Recommendations from this study include further research on a large cohort of radiographers within a clinical practice environment to allow consensus on the results. Recommendations for RRs within this area include adherence to an agreed scheme of work, routine governance, regular audit and continuing professional development to support advanced practice roles.

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