Concordance between a neuroradiologist, a consultant radiologist and trained reporting radiographers interpreting MRI head examinations: an empirical study

Abstract

Introduction: This study assessed agreement between MRI reporting radiographers and a consultant radiologist compared with an index neuroradiologist when reporting MRI head (brain/internal auditory meati [IAMs]) examinations. The effect on patient management of any discordant reports was also examined.

Methods: Two trained MRI reporting radiographers (RRs), a consultant radiologist (CR) and an index neuroradiologist (INR) reported on a random sample of 210 MRI examinations. The radiographers reported during clinical practice and the radiologists in clinical practice conditions. Two independent consultant physicians (neuro-rehabilitation and neuropsychiatry) compared these reports with the index neuroradiologist report for agreement and the clinical importance of discrepant reports.

Results: Overall observer agreement between the RRs and CR was comparable in relation to agreement with the INR: RR; 93/210 (44.3%); and the CR; 83/210 (39.4%) for all head MRI examinations (p=0.32). For brain examinations the difference was similar: RR; 64/180 (35.6%); and CR; 54/190 (30.0%), p=0.26. Agreement rates for the IAMs examinations were identical, 29/30 (97.7%).

For all head MRI examinations (n=210) there was a very small observed difference of <0.5% in mean agreement between the reporting radiographers and the consultant radiologist (p=0.92) for examinations where a major disagreement would have been likely to have led to a change in patient management.

Conclusion: MRI reporting radiographers reported during clinical practice on MRI head examinations to a level of agreement comparable with a consultant radiologist.

Implications for practice:

This is an area in which radiographers could provide additional reporting roles to the reporting service to increase capacity. Wider potential benefits include cost-effectiveness and role development/retention of radiographers.

Keywords: Magnetic Resonance Imaging; Head; Brain; Agreement; Radiographers; Radiologists

Introduction

Medical imaging has a central role in modern healthcare. Sustained increased in cross-sectional imaging has occurred, and although a temporary reduction was seen during the first wave of COVID-19, imaging volumes have rebounded quickly as health systems implement recovery plans [1]. A shortage in doctors and the need to address increasing demand in a health care system with scarce resources brought about changes in Government policy that promoted a more flexible and creative use of allied healthcare professional skills [2]. This longstanding challenge facing clinical imaging departments, the burgeoning rise in workload, associated with a national shortage of radiologists and radiographers [3,4] has resulted in the development of radiographers to provide a formal reporting role [5,6,7]. Team working, including integrated radiographer reporting, is advocated as one solution to meet demand and improve patient outcomes [8]. A recent cancer workforce plan recognised the contribution of reporting radiographers and funding has been provided for 300 additional reporting radiographers [9]. There is accepted definitive evidence that radiographers, with appropriate education and training, can provide accurate reports on skeletal radiographs [10,11,12] and chest radiographs [13,14,15]. As a result more recently, this principle has been extended to reporting of MRI examinations [16,17,18]. A recent report stated that reporting radiographers are currently providing reports on MRI examinations in 27/69 (39.1%) of the hospitals that responded to a survey related to advanced practice roles in diagnostic radiography [19]. Following the progress made with radiographers reporting plain radiographs (skeletal and chest) and MRI (knee and lumbar spine examinations) a postgraduate course was developed to educate and train selected radiographers to report MRI

examinations of the head [20], which included reporting of brain and IAM examinations.

Following successful completion of the postgraduate course and a period of supervision, two radiographers commenced contributing to the MRI head reporting workload under a scheme of work agreed with the lead consultant radiologist, clinical services manager and the employer [21]. The following were not included in the local protocol and therefore were excluded from this study: MRI Orbits, MRI Pituitary, MRI brain with contrast for Multiple Sclerosis follow-up. The aim of this study was to examine the performance of the radiographers reporting MRI head (selected brain and Internal Auditory Meati [IAMs] examinations), with and without administration of contrast media, following implementation in clinical practice.

Objectives

The primary objective was to assess the inter-observer agreement between reporting radiographers (RRs) and a consultant radiologist (CR) compared with an index neuroradiologist (INR) when reporting MRI examinations of the head.

The secondary objective was to assess the effect on patient outcome when radiographer and radiologist reports disagreed with the index radiologist report.

Methods

There is considerable inter-observer variation between experts, such as consultant radiologists, when reporting MRI examinations. Previous studies have found poor to good agreement for the collateral, posterior cruciate and anterior cruciate ligaments, respectively, (k=0.1-0.6) when reporting knee examinations [22] and; moderate agreement (k=0.54) for the presence and type of disc abnormality in the lumbar spine [16]. Therefore rather than measure reporting accuracy in terms of sensitivity

and specificity, observer agreement in reporting of MRI examinations for two reporting radiographers (RR1/RR2) and a consultant radiologist (CR) was assessed in comparison to the index report of an independent consultant neuroradiologist (INR). The two radiographers in this study had over ten years experience in MRI and had completed a postgraduate programme in clinical reporting of MRI examinations (knee, cervical / lumbar spine and brain/internal auditory meati [IAMs]) in 2008. They each had over 6 years experience of independently reporting MRI knee and lumbar spine examinations; and 2 years experience of independently reporting brain/IAMs examinations. The consultant radiologist had over 10 years experience as a consultant in general radiology that included head MRI reporting. The index neuroradiologist, whose reports were compared with the reports of the reporting radiographers; and the consultant radiologist for agreement, was a neuroradiologist with 3 years consultant experience.

Clinicians integrate imaging reports in different ways. Variation in the content between reports that reach the same conclusion could influence clinicians' diagnostic reasoning or confidence in different ways. Factors, including on clinician preferences and experience, and could affect clinicians' diagnosis, management plans and ultimately patient outcome [23]. Therefore, two consultant physicians (CP1/CP2); one with 15 years experience in neurorehabilitation medicine with regular weekly attendance of neuroradiology multidisciplinary team meetings (MDT) on various MRI scans in the hospital; and the other with 14 years experience in neuropsychiatry, compared the two pairs of reports (RR/INR) and (CR/INR) and judged whether any variation between RR and INR; and CR and INR, would have had an effect on expected patient management and outcome. These two consultants regularly refer their patients for MRI / Computed Tomography (CT) brain scans (with and without

contrast) for a 19 bed inpatient neurorehabilitation unit. At the weekly multidisciplinary radiology meetings 10-12 neurologists discuss complicated images of the brain (and spinal cord), where there are disagreements amongst the consultants, or radiology reports do not confirm the clinical diagnosis. Second or third opinions are sought from peers and/or teaching points explored for trainees and junior medical staff in neurology and neurorehabilitation. The investigations that were included in this study (Table 1) were typical of the range of cases which these physicians regularly refer patients for; review; and discuss in MDTs.

The physicians had access to the clinical details (referral source; patient age and gender) from the original MRI request form and were blinded to who made the observer reports but not that of the index neuroradiologist's report which was regarded as the reference standard. To judge the clinical importance of any discordance between the pairs of reports (RR and INR; and CR and INR) the physicians chose one of the following options:

0 Reports agree, no difference in patient management and therefore no effect on patient outcome;

1 Minor disagreement (clinically unimportant) unlikely to lead to a change in patient management, and no effect on patient outcome;

2 Disagreement in reports with significant clinical impact likely to lead to a change in patient management that would affect patient outcome.

Based on Brealey et al, 2013 [18] and Briggs et al, 2008 [24].

The two physicians used consensus development by judgement. If the physicians disagreed initially, the case was discussed, and a consensus agreement was recorded with a relevant comment.

Where a disagreement was evident between the RR/INR and CR/INR pairs of reports no attempt was made to assess which, if either, of the two discordant reports was correct as this study was designed to investigate agreement not accuracy.

Imaging techniques

The images for this study were acquired on either a Siemens Harmony 1 Tesla or a General Electric (GE) 3 Tesla HDXT MRI scanner. The sequences employed in the brain examinations varied depending on the clinical indications and scanner utilised. The protocols for all examinations included T2 weighted spin echo (SE) or fast spin echo (FSE) axial images through the brain from foramen magnum to vertex, T1 SE axial images planned to copy the T2 and a Fluid Attenuated Inversion Recovery (FLAIR) Sagittal sequence. In addition, examinations performed on the 3 Tesla scanner had additional Diffusion Weighted Imaging (DWI) axial images with calculated Apparent Diffusion Coefficient (ADC) and Exponential Apparent Diffusion Coefficient (eADC) maps. Where additional sequences were used they were in response to the clinical indications: Coronal Turbo Inversion Recovery (TIR) for epilepsy; and T1 weighted axial and T1 weighted coronal post contrast images, where appropriate. For imaging of the Internal Auditory Meati (IAMs) thin slice (1.8mm), heavily T2 weighted axial imaging was performed; T2 fast imaging employing steady-state acquisition (FIESTA) or T2 constructive interference in steady-state (CISS). Imaging of the IAMs was often was accompanied by routine brain imaging as a standard procedure for more generalised symptoms.

Sample Size

Previous studies have demonstrated discrepancies between neuroradiologists and general radiologists when reporting cross sectional neuroimaging examinations. As a result of secondary or follow up reporting by a neuroradiologist the patient

management was found to have changed in 15.9% of cases [25] and in another study a major discrepancy rate of 13% was demonstrated [24]. McCarron et al also found a 13.4% discrepancy rate [26]. We therefore assumed the accuracy of a non-specialist consultant radiologist to be 87%. A previous study, which investigated the performance of radiographers when reporting MRI neurological investigations in an academic examination setting found a mean agreement rate of 88.37% [19]. We therefore assumed that the accuracy of the radiographers in this study would not be significantly different to the consultant radiologist.

With chosen values of 0.05 and 0.2, for Type I (incorrect rejection of null hypothesis) and Type II (incorrect acceptance of null hypothesis) errors, respectively, and considering a 5% inferiority difference to be acceptable in clinical practice, a sample size of 210 examinations was required [27]. A non-inferiority approach is appropriate as the aim of the study was to determine if MRI brain reporting by radiographers was no worse than a consultant radiologist.

Statistical analyses

Agreement in reports, between the RRs and the CR, compared with the index radiologist was calculated as percentages with 95% confidence intervals, using the Wilson procedure [28]. The difference between proportions test was used to measure the significance of any differences in the agreement rates (overall, minor and major) between a) the RRs and the INR; and b) between the consultant radiologist and INR. The major disagreement rate between the two reporting radiographers was also examined for any statistically significant differences.

Ethics

Ethical compliance of the proposed study was confirmed by Canterbury Christ Church University (Ref: 14/NHP/Piper) and consequently did not require consent from patients or staff. In addition, the study was not considered to involve risk to patients so the Research and Development Service for Medway Maritime Hospital decided that Research Governance approval was not necessary.

Results

A total of 2,108 examinations were eligible for inclusion in the consecutive series sample which extended from March 2010 to July 2011 (Figure 1). To adequately meet the sample size requirement, 1,874 examinations were randomly excluded using Microsoft Excel® (Microsoft Excel, Redmond, WA) random number generation; five examinations were excluded due to incomplete data. Reporting of MRI IAMs examinations has been recognised as being less complex/time consuming than brain reporting [29] and the prevalence of abnormal appearances is also known to be low [16,30]. Additionally, it has been demonstrated that agreement between observers, when interpreting IAMs examinations, is high [16,17]. A small number of excess IAMs examinations (n=19) were therefore also excluded to prevent biasing the sample in favour of less complex examinations with a high proportion of normal cases. This resulted in a sub set of 30 IAMs examinations; which is often regarded as an adequate sample size for small studies [31].

Two hundred and ten (n=210) MRI head examinations (180 brain; 30 internal auditory meati [IAM]) examinations were therefore included in the final study. The demographic characteristics of the patients included in the study are shown in Table 1, which shows that MRI brain examinations had been completed on 180 patients:

74 male; mean age 54 years; 106 female; mean age 51 years. The source of referral and the reasons for referral are shown in Table 2. The majority of patients referred for MRI brain examinations 174/180 (96.7%) had been referred as an outpatient; and 3/180% as an inpatient or from a GP. Thirty patients (all referred as outpatients) had MRI IAMs examinations (10 male; mean age 56; and 20 female; mean age 52;). The main reasons for referral for brain examinations were headaches (16%) and dizziness (13%); the majority of IAMs examinations were conducted following loss of balance, unsteadiness, fall/s (23%) or vertigo (17%).

Figure 1, which illustrates the flow of examinations through the study, shows that the two reporting radiographers (RR1/RR2) had reported 2108 examinations that were eligible for inclusion. Of the 210 examinations randomly selected for the study RR1and RR2 had reported 115/210 (54.8%) and 95/210 (45.2%); the consultant radiologist (CR) and the index neuroradiologist (INR) retrospectively reported all 210 examinations. Table 3 presents the observer agreement rates (and 95% Confidence Intervals) for all MRI head examinations. The overall agreement between the reporting radiographers and the index neuroradiologist was 93/210; 44.3%, (95% CI, 37.7 - 51.1); and for the consultant radiologist and index neuroradiologist was 83/210; 39.4% (95% CI, 33.2 - 46.3) with no statistically significant difference between the agreement rates for the two groups ($z=0.99$, $p=0.32$). The level of major disagreement, with significant impact likely to have led to a change in patient management, was also similar when comparing the two groups: RRs and INR; 64/210 (30.48%); and CR and INR; 65/210 (30.95%) and again no significant difference was demonstrated ($z=-0.11$, $p=0.93$).

Although the reporting radiographers did not report an identical number of examinations (RR1; 115 and RR2; 95), there was no significant difference between

the proportion of their individual major disagreement rates when their individual reports were compared to those of the neuroradiologist; RR1, 34/115 (29.6%); and RR2, 30/95 (31.6%) z=-0.32, p=0.75. Separate figures for the brain examinations are included in Table 4. The overall agreement; and minor/major disagreement rates are also illustrated in Figure 2. No statistically significant differences were found between the overall agreement, minor agreement or major agreement rates between the reporting radiographers and neuroradiologist; and the consultant radiologist and the neuroradiologist for the brain examinations specifically (z=1.12, p=0.26; z=-1.02, p=0.31; and z=-0.11, p=0.91, respectively). Table 5 demonstrates identical agreement rates (97.7%) between the two groups and the neuroradiologist for the IAMs examinations.

Table 6 outlines the areas of variance between the pairs of reports, where a major disagreement had been identified with significant impact likely to have led to a change in patient management. The areas of variance included in Table 6 are ranked by the total number of occurrences for all observers. When compared to the index report provided by the neuroradiologist, the five most common areas, where variation occurred were: (i) further imaging not being recommended by the reporting radiographers, n=25/87 (28.7%) and the consultant radiologist, n=18/103 (17.5); (ii) small vessel disease not being reported by the consultant radiologist, n=17/103 (16.5%) and the reporting radiographer, n=11/87 (12.6%); (iii) recommend referral to another specialist (CR; 11/103 (10.7%), and RR; 6/87 (6.9) ; (iv) paranasal sinus disease not reported by the consultant radiologist, n=7/103 (6.8%) or the reporting radiographer, n=6/87 (6.9%); and (v) prominent lymph nodes not reported by the consultant radiologist, n=9/103 (8.7%) and the reporting radiographer, n=3/87 (3.4%).

Senior radiologist colleagues at the hospital trust were informed of all major discrepancies to enable appropriate action to be taken, as necessary; no records were kept of any follow up.

Discussion

The principal findings of this study are that for the reporting of MRI examinations of the brain and IAMs there is comparable agreement between trained MRI reporting radiographers and a consultant radiologist with that of an index neuroradiologist (INR). The overall agreement between the reporting radiographers and the INR; and the consultant radiologist and the INR, ranged from 39.5% (83/210: CR) to 44.3% (93/210: RRs). Sufficient disagreement with the index radiologists report to be likely to have impacted on patient management and outcome was found: RRs; 64/210 (30.48%) and CR; 65/210 (30.95%) of reports. Any small differences in the agreement rates (overall, minor and major) between the two groups were not statistically significant, which is similar to the findings of a previous study which assessed agreement between reporting radiographers and consultant radiologists when reporting MRI examinations of the knee and lumbar spine [18]. The 30% major disagreement rate found in our study, could be considered low concordance, however, this figure is similar to the rate found in other studies, one of which found 66% of examinations were in complete agreement when the general radiologist report was compared to the neuroradiologist report [24]. Similar studies reported 33.2% and 30.9% levels of disagreement in primary and secondary findings when neuroradiologist reports have been compared to reports provided by general radiologists [25,26]. In the same studies, an additional 10.3% and 13.7% of cases were in disagreement as further investigations had been recommended by the neuroradiologist [25,26]. These figures are also similar to those found in our study

where the neuroradiologist suggested further imaging and our observers did not make this recommendation (RR; 11.9% and CR; 8.6%) or referral to another specialist (RR; 2.9% and CR; 5.2%). It would be unwise, however, to attempt to compare the results of these studies [24, 25,26,] too precisely with our findings, as the previous studies included examinations that had been referred by a neurologist / general radiologist to a neuroradiologist for a second opinion/review; and the grading systems used were not identical. More recently it has been reported that the use of neuroimaging team meetings to provide a second opinion found clinically important discrepancies in 18.9% of patients [32].

The strive to achieve high levels of interobserver agreement is known to be challenging when interpreting neurological MRI examinations, even for expert reporters. Granerod et al, described the agreement between three neuroradiologists as moderate (k=0.54) when rating MRI scans as normal or abnormal in an encephalitis study [33]. Another study [34] which investigated the interobserver reliability between neuroradiologists, when reporting MRI abnormalities of the brain, demonstrated a range of Kappa values (site of cerebral infarct, k=0.14; severity of atrophy, k=0.31; number of white matter lesions (WML) in the posterior fossa, k=0.55); and number of WMLs in cerebral hemispheres, k=0.76) indicating poor, fair, moderate and good agreement, respectively [35].

In our study the five most frequently occurring areas of variation between the reports of the observers and the neuroradiologist were: (i) further imaging not being recommended; small vessel disease not being reported; referral to another specialist not recommended; paranasal sinus disease not reported; and prominent lymph nodes not reported.

The reporting radiographers in this study were unable to refer for ionising radiation procedures without discussion with a consultant radiologist. Any discussions would have been recorded within the final report. As part of the locally agreed protocol, the reporting radiographers within this study were able to refer for further MRI scans – both with and without contrast media. Contrast studies were approved by the reporting radiographer using the PGD (Patient Group Direction) framework.

Second reporting of neurological studies by a neuroradiologist could improve the diagnostic accuracy in the DGH setting, however, this approach is probably unrealistic for many NHS Trusts in the UK, due to the shortage of radiologists [3].

Limitations

There are some limitations to our study. Firstly, the way in which cases to be included were randomly selected could have been improved. However, a number of patients had been referred for both MRI brain and MRI IAMs examinations and as result stratified randomisation and the exclusion of cases were not straightforward. The small number of MRI reporting radiographer and general radiologist observers included in this study also means that there is limited generalisability of the results. The fact that the examinations all came from a single institution may also have an effect of the generalisability of the results due to the differences in scanner technologies and sequences used at other institutions. There were also differences between the scanners employed in this study and image quality was variable due to the lower image resolution and lower signal to noise ratio of the 1 Tesla scanner; any differences, however, between the scanners in terms of report agreement, were not investigated.

The MRI reporting radiographers had reported the examinations as part of their routine clinical practice and greater attempts could have been made to select the

same number of examinations reported by each radiographer. The possibility of limited selection bias cannot be excluded, although this is less likely as both reporting radiographers were reporting as part of an agreed protocol as outlined previously. It was also not possible to know to what extent advice was sought during this process however, reporting of clinical diagnostic imaging examinations should always be carried out as part of a team process and all reporting practitioners should consult with more experienced colleagues, as the need arises. We took all possible steps to exclude cases which had been discussed with others, when this information had been recorded, as the main aim of this study was to investigate the ability of reporting radiographers when reporting in clinical practice. The consultant radiologist did not work at the same department / NHS Trust, neither did the neuroradiologist. As this was a controlled study, both (CR and INR) knew of the purpose of the research and therefore this could have influenced their reporting behaviours [36], however, all pairs of reports were compared by the independent physicians who were blinded to the identity of the observers when comparing reports to that of the index neuroradiologist. A more detailed exploration of the differences between the reports could be completed as part of a subsequent qualitative analysis.

Conclusion

Previous research has found that MR radiographers with appropriate postgraduate education and training can report MRI examinations of the knee and lumbar spine, in clinical practice conditions, to a level of similar agreement comparable with non-musculoskeletal consultant radiologists [18].

The recent report [19] which analysed replies from respondents in hospitals in England (n=69) found that radiographers are currently reporting a wide range of MRI examinations including brain and IAMs, 10/69 (14.5%).

The findings of our study confirm that this practice could be extended more widely, as the MR reporting radiographers in this study provided brain and IAMs reports in clinical practice to similar levels of agreement with a neuroradiologist, as those provided by a general consultant radiologist.

Implications for practice

Our study contributes to the growing evidence base that selected radiographers with appropriate postgraduate education and training can report on complex MRI examinations [17,18].

This is an area in which radiographers could provide a reporting role and contribute to patient care. Future work is indicated which could be a multi-centre study of radiographers and radiologists observer agreement for the reporting of MRI head examinations during routine clinical practice including an evaluation of the related economic aspects.

Conflict of interest statement

None

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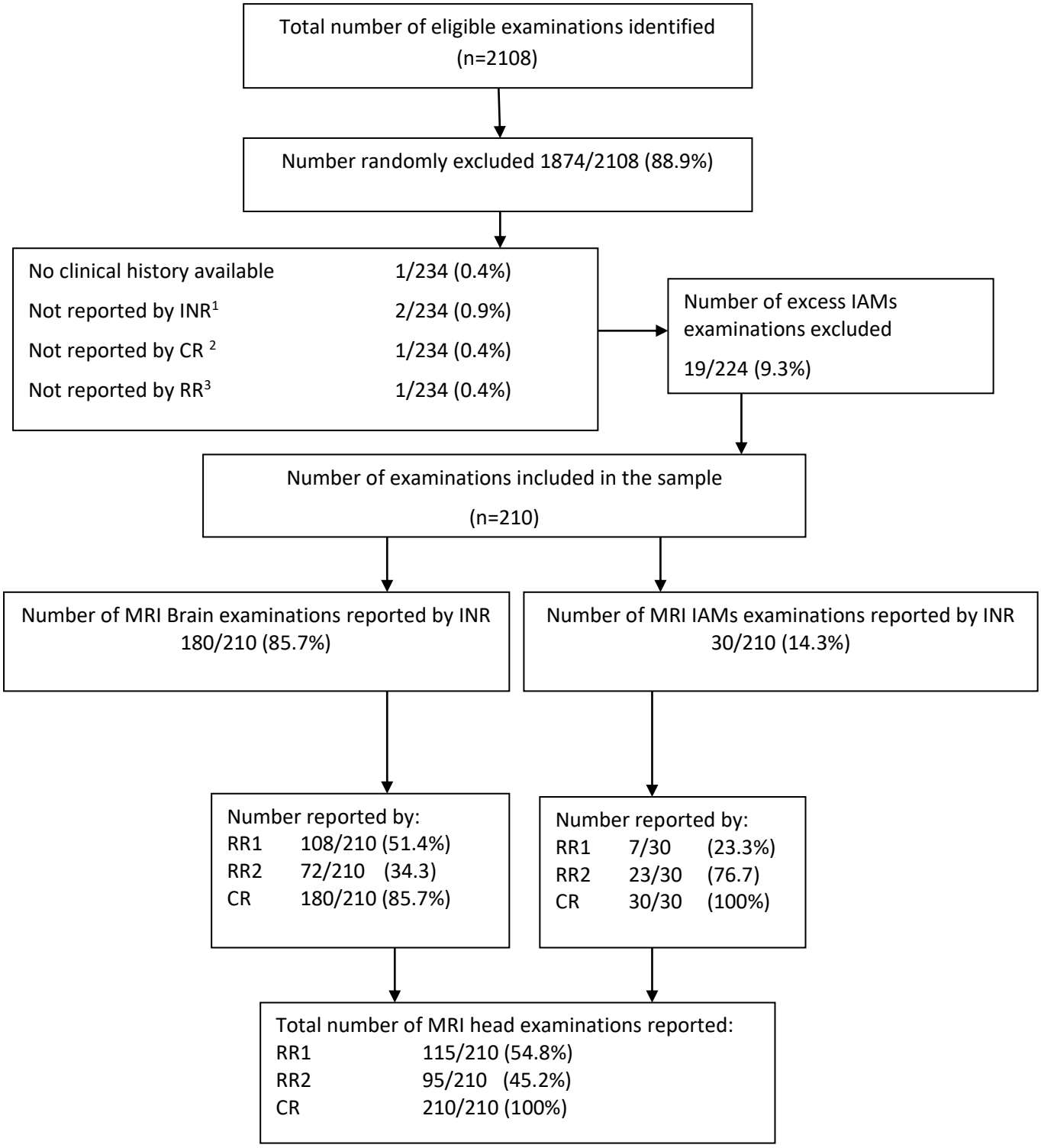
Figure 1 Flowchart of MRI examinations included in the study



[1] Index neuroradiologist

[2] Consultant radiologist

[3] Reporting radiographer

Figure 2 Agreement with the index neuroradiologist report

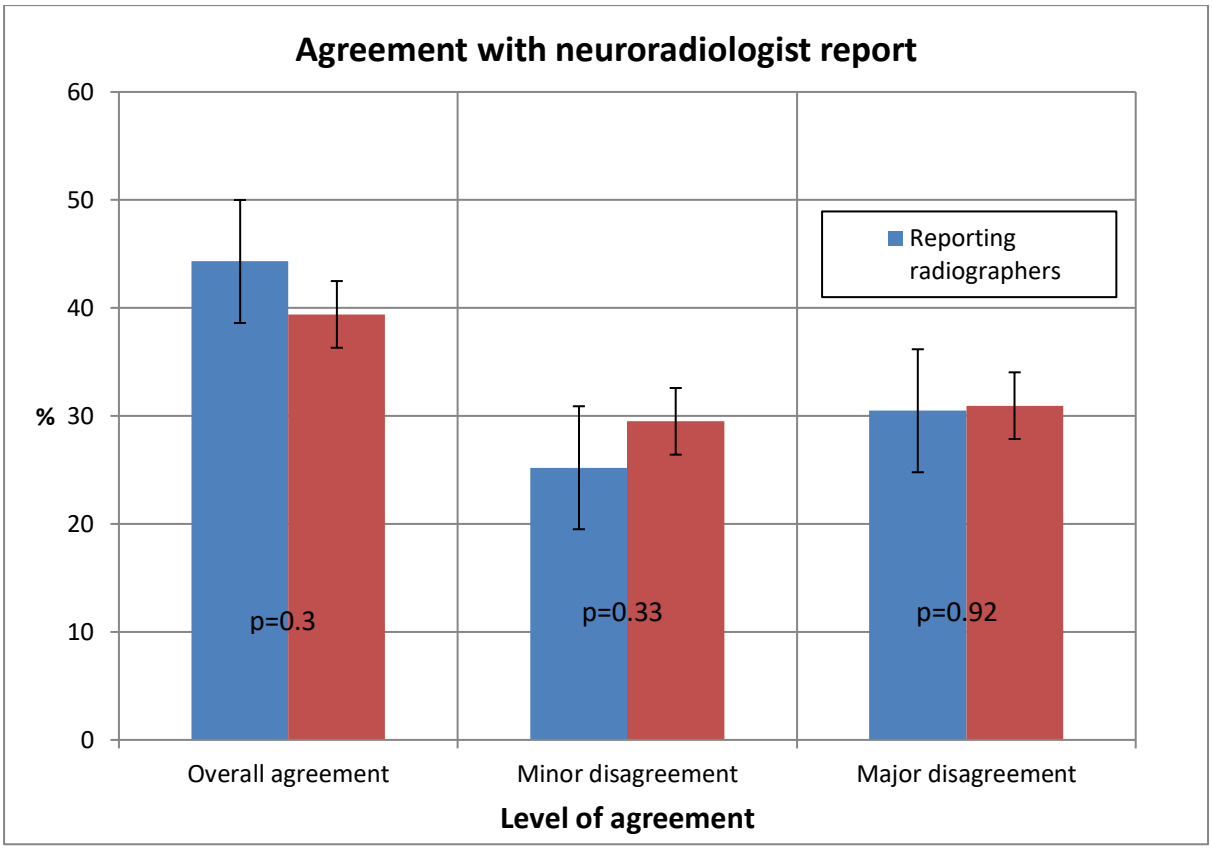


Table 1 Demographic characteristics of patients included

Brain examinations (n=180)		**Internal auditory meati (IAMs) examinations (n=30)**	
Characteristic	Value	Characteristic	Value
Sex: Male, n (%)	74/180 (41.1)	Sex: male, n (%)	10/30 (33.3)
Age, year		Age, year	
N	74	N	10
Mean (SD)	54 (18)	Mean (SD)	56 (17)
Female, n (%)	106/180 (58.9)	Female, n (%)	20/30 (66.7)
Age, year		Age, year	
N	106	N	20
Mean (SD)	51 (18)	Mean (SD)	529160

Table 2 Referral source and reasons for referral

Brain examinations (n=180)		**Internal auditory meati (IAMs) examinations (n=30)**	
Referral source:		**Referral source:**	
Outpatient, n (%)	174/180 (96.7)	Outpatient, n (%)	30/30 (100)
Inpatient, n (%)	3/180 (1.5)		
GP, n (%)	3/180 (1.5)		
Reasons for referral:	n / 310 (%)*	**Reasons for referral:**	n / 52 (%)*
Headache/s	50 (16)	Loss of balance, unsteadiness, fall/s	12 (23)
Dizziness	41 (13)	Vertigo	9 (17)
Numbness	24 (8)	Tinnitus	8 (15)
Fit / epilepsy	24 (8)	Hearing loss	8 (15)
Hearing problems	21 (7)	Nerve palsy, numbness	7 (13)
Vertigo	21 (7)	Dizziness	6 (12)
Demyelinating disease	17 (5)	Headaches/s	2 (4)
Tinnitus	17 (5)		
Referral following previous imaging, other investigation	11 (4)		
Weakness	11 (4)		
Speech problems	11 (4)		
Loss of consciousness	11 (4)		
Visual problems	10 (3)		
Memory problems	9 (3)		
Trauma	6 (1.9)		
Nerve palsy	5 (1.6)		
Confusion	5 (1.6)		
Stroke, TIA, aneurysm	4(1.3)		
Metastases, recurrence	4 (1.3)		
Parkinson's disease	2 (0.6)		
Amnesia	2 (0.6)		
Coordination problems	1 (0.3)		
Tremor	1 (0.3)		
Hydrocephalus	1 (0.3)		
Previous surgery	1 (0.3)		

***** A number of patients, 152/180 (84.4%) were referred for more than one reason. All reasons are included in Table 2

Table 3 Observer agreement for reporting all MRI examinations (brain and IAMs) - index neuroradiologist and reporting radiographers; and index neuroradiologist and consultant radiologist

Report agreement criteria	**Agreement with neuroradiologist (index report)**	**Observers** (number of images)		**Values**	
		RR1/RR2[1] (n=210[*])	**CR[2]** (n=210)	**Z**	**p**
Agree the examination is normal, n (%)	No Yes	137 (65.2) 73 (34.8)	147 (70.0) 63 (30.0)	1.04	0.29
Overall agreement, n (%) [95% CI]		93 (44.3) [37.7 - 51.1]	83 (39.5) [33.2 - 46.3]	0.99	0.32
Minor disagreement, unlikely to lead to a change in patient management, n (%) [95% CI]		53 (25.2) [19.9 - 31.5]	62 (29.5) [23.8 - 36.0]	-0.99	0.33
Major disagreement with significant impact likely to lead to a change in patient management, n (%) [95% CI]		64 (30.48)[**] [24.7 - 37.0]	65 (30.95) [25.1 - 37.5]	-0.11	0.93

* The two reporting radiographers[1] (RR1 and RR2) each reported 115 and 95 separate examinations, respectively; 210 in total.

** The individual major disagreement rates of observers A and B were 29.6% (34/115) and 31.6% (30/95) and not statistically different (z = -0.32, p = 0.75).

[2] Consultant radiologist

Table 4 Observer agreement for reporting MRI Brain examinations

Report agreement criteria	**Agree**	**Observers** (number of images)		**Values**	
		RR1/RR2[1] (n=180*)	**CR** (n=180)	**Z**	**p**
Agree the examination is normal, n (%)	No Yes	138 (76.7) 42 (23.3)	146 (81.1) 34 (18.9)	1.03	0.30
Overall agreement % [95% CI]		64 (35.6) [28.9 - 42.8]	54 (30.0) [23.8 - 37.1]	1.12	0.26
Minor disagreement, unlikely to lead to a change in patient management		52 (28.9) [22.8 - 35.9]	61 (33.9) [27.4 - 41.1]	-1.02	0.31
Major disagreement with significant impact likely to lead to a change in patient management		64 (35.6) [28.9 - 42.8]	65 (36.1) [29.5 - 43.4]	-0.11	0.91

* The two reporting radiographers[1] (RR1/RR2) each reported 108 and 72 separate examinations, respectively; 180 in total.

[2] Consultant radiologist

Table 5 Observer agreement for reporting MRI IAMs examinations

Report agreement criteria	**Agree**	**Observers** (number of images)	
		RR1/RR2[1] (n=30*)	**CR[2]** (n=30)
Agree the examination is normal, n (%)	No Yes	1 (3.3) 29 (97.7)	1 (3.3) 29 (97.7)
Overall agreement % [95% CI]		29 (97.7) [83.3 - 99.4]	29 (97) [83.3 - 99.4]
Minor disagreement, unlikely to lead to a change in patient management		1 (3.3)	1 (3.3)
Major disagreement with significant impact likely to lead to a change in patient management		0 (0)	0 (0)

* The two reporting radiographers[1] (RR1/RR2) each reported 7 and 23 separate examinations, respectively; 30 in total.

[2] Consultant radiologist

Table 6 Areas of variation between pairs of reports (Major disagreement)

Area of variation between reports	Total number of all occurrences, n (%)		
	A[1]	B[2]	A + B
Further imaging recommended by the index neuroradiologist (INR) and not by A or B	25 (11.9)	18 (8.6%)	43
Small vessel disease not reported by A or B	11 (5.2%)	17 (8.1%)	28
Referral to other specialist not recommended by A or B	6 (2.9%)	11 (5.2%)	17
Paranasal sinus disease not reported by A or B	6 (2.9%)	7 (3.3%)	13
Prominent lymph nodes not reported by A or B	3 (1.4%)	9 (4.3%)	12
Possibility of demyelinating disease not raised by A or B	5 (2.4%)	6 (2.9%)	11
Other neurological disorder not reported by A or B	5 (2.4%)	6 (2.9%)	11
Possible neoplasm not reported by A or B	4 (1.9%)	4 (1.9%)	8
Old infarction not reported by A or B	5 (2.4%)	2 (1%)	7
Mild cerebellar tonsillar ectopia not reported by A or B	1 (<1%)	5 (2.4%)	6
Hydrocephalus not reported by A or B	2 (1%)	3 (1.4%)	5
Small vessel disease reported by A or B and not by the index	3 (1.4%)	1 (<1%)	4
Paranasal sinus disease reported by A or B and not reported by the index	3 (1.4%)	1 (<1%)	4
Further imaging recommended by A or B and not by the index	2 (1%)	2 (1%)	4
Severity of microangiopathy under reported by A or B	3 (1.4%)	0	3
Chiari appearance not reported by A or B	2 (1%)	1 (<1%)	3
Possible neoplasm reported by A or B and not by the index	0 (<1%)	3 (1.4%)	3
Mastoid air cell changes reported by A or B and not by the index	1 (<1%)	1 (<1%)	2
Possibility of AVM raised by A or B and not reported by the index	1 (<1%)	1 (<1%)	2
Possibility of demyelinating disease raised by A or B and not by the index	0	2 (1%)	2
Temporal lobe changes not reported by A or B	1 (<1%)	0	1
Specific location of all metastases not reported by A or B	1 (<1%)	0	1
Cervical spine/cord abnormality not reported by A or B	0	1(<1%)	1
Cerebral/cerebellar atrophy reported by A or B and not reported by the index	0	1(<1%)	1
Hippocampal sclerosis reported by A or B and not reported by the index	0	1(<1%)	1
Total	**87***	**103****	

[1] Reporting radiographers
[2] Consultant radiologist

* 64 examinations in which major disagreement/s identified
** 65 examinations in which major disagreement/s identified

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