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User guide for Inferior Frontal Sulcal Hyperintensity (IFSH) Scale and related template

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User guide for IFSH Scale (Inferior Frontal Sulcal Hyperintensity Scale)

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The Inferior Frontal Sulcal Hyperintensity (IFSH) Scale is a rating system designed to describe the amount of hyperintensities in the inferior frontal region of the brain on 3T MRI. We considered IFSH to be hyperintensity seen in the cerebrospinal fluid (CSF) on fluid-attenuated inversion recovery (FLAIR) in the three inferior frontal sulci, comprising the central sulcus between gyrus recti, and the sulci immediately to the right and left (namely olfactory sulci) (**Figure I**).

We developed an initial pilot IFSH scale on first principles but simplified it after testing by two observers on a subset of cases highlighted points that were prone to variation in interpretation. These resulting refinements were then incorporated into a revised scale. The scale has been designed and tested at 3T on FLAIR images: it has not been tested at lower or higher field strengths and therefore should not be used without further development and testing at the alternative field strength. It does not apply to other sequences apart from FLAIR.

When present, IFSH are easily identified on FLAIR sequence at 3T (**Figure I**). 3D FLAIR (ie volume scan with isotropic or near-isotropic voxels rather than 2D axial slices) is recommended for IFSH rating.

The IFSH rating scale is shown on the next page. This is followed by a more detailed description of rating instructions. Finally, there are some examples, including sources of inter-observer variation, knowledge of which should help reduce the inter-/intra-observer variability.

Inferior Frontal Sulcal Hyperintensity (IFSH) Scale

Study ID: _____ Date of MRI scan: _____

Method of rating

To standardize visualization and overcome effects of different head positioning in the MRI scanner and variability of head sizes, we orientate all scans parallel to the floor of the anterior cranial fossa using the multi-planar reconstruction (MPR) function (**Figure II**) in a standard radiological Picture Archiving and Communication System (PACS), to align each subject's axial slices in the same plane to assess the inferior frontal sulci for hyperintense CSF signal.

Each sulcus is scored from 0 to 3 (**Table I**): 0 = none of sulcus affected; 1 = less than half of sulcus length affected; 2 = at least half of sulcus length affected; 3 = most or whole of sulcus length affected.

The scores of the 3 sulci are summed to give an overall Inferior Frontal Sulcal Hyperintensity (IFSH) score. The total IFSH score ranges from 0 to 9 (**Table II**).

Table I. Scoring system for each individual sulcus of inferior frontal sulci for FLAIR hyperintensity.

Score	Extent of sulcal involvement
0	none of sulcus affected
1	less than half of sulcus length affected
2	at least half of sulcus length affected
3	most or whole of sulcus length affected

Table II. Overall score for inferior frontal sulci for FLAIR hyperintensity.

Right sulcus	0	1	2	3
Central sulcus	0	1	2	3
Left sulcus	0	1	2	3
<u>Overall score</u>	____ / 9			

Flow chart of scoring instructions

Step 1: Orientate the scan parallel to the floor of anterior cranial fossa in multi-planar reconstruction (MPR) mode (Figure II).



Step 2: Determine if any inferior frontal sulcal hyperintensity (IFSH) is present / absent in each individual sulcus. If there are any IFSH **present** in any individual sulcus, the score of this sulcus will be **at least 1**.



Step 3: Score for extent of IFSH/sulcal involvement (Table I) in each of the 3 sulci **superior to the axial 'reference slice'** * (Figure III).



Step 4: Add up the scores[#] from all 3 individual sulci for an overall score of IFSH (Table II).

If there are some IFSH present below/in the **reference slice** while no IFSH shown above the **reference slice**, the score of this sulcus will be 1.

***Description of 'reference slice'**

- 1) Start from the most inferior (caudad) axial slice of the inferior frontal sulci, scroll up superiorly slice by slice to identify the 1st slice with all 3 individual sulci (the central sulcus between the gyrus recti, and the olfactory sulci) shown clearly. This is regarded as the **reference slice**. (Figure III)
- 2) This **reference slice** will not be used for scoring of extent of sulcal involvement (due to a commonly encountered problem of sulcal length at this level and inferior to this level being too short for accurate scoring of proportionality of sulcal involvement).
- 3) Above **the reference slice** (ie in direction of vertex), scroll superiorly through the different slices of inferior frontal sulci to determine maximum length of hyperintensity visible as per Table I. The maximum score is recorded.

Figure I. Example of Inferior Frontal Sulcal Hyperintensity (IFSH) on FLAIR sequence.

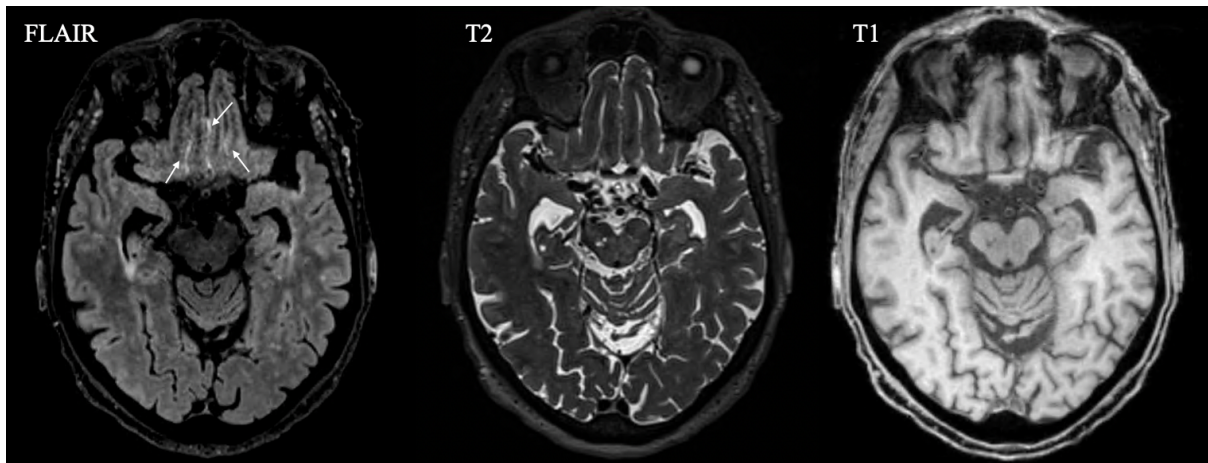


Figure II. Example of orientating the scan parallel to the floor of the anterior cranial fossa in multi-planar reconstruction (MPR) mode.

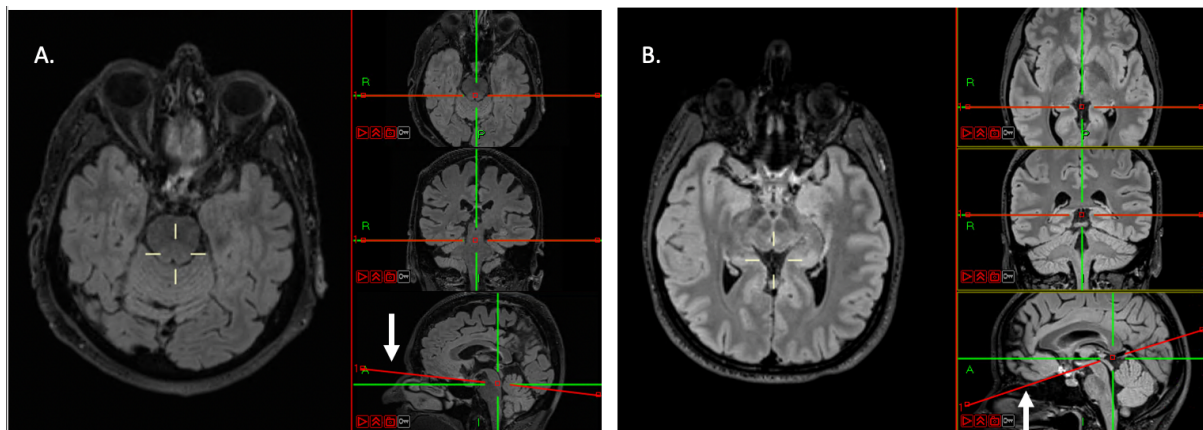


Figure III. Example of determining the ‘reference slice’.



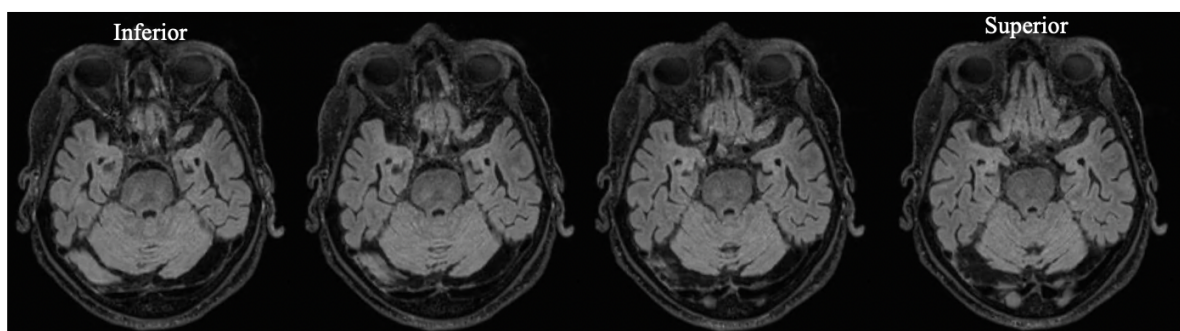
↑
Cannot see all three sulci clearly.

↑
Can see all three sulci clearly,
regarded as *reference slice*.

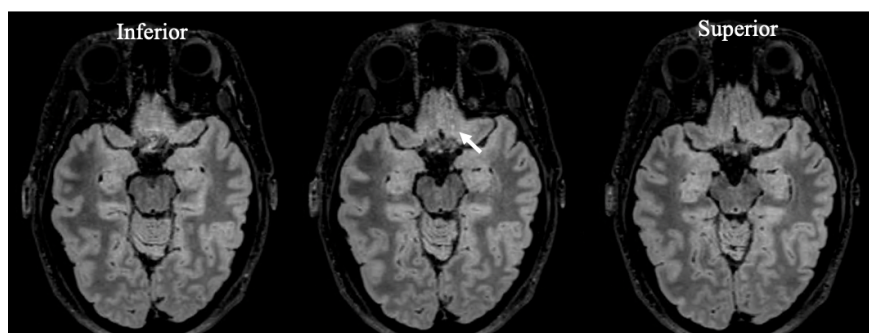
↑
Determine IFSH score using slices
above *reference slice*.

The ‘reference slice’ is the most inferior (caudad) slice on which all three sulci can be seen clearly.

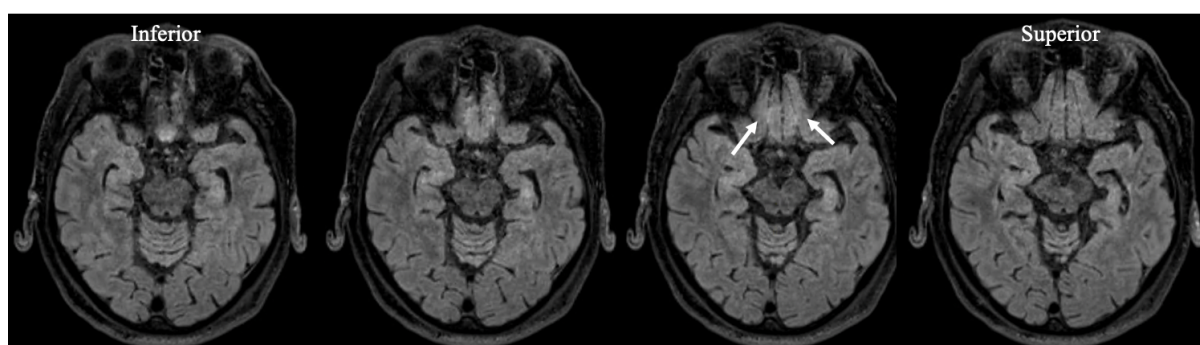
Rating examples



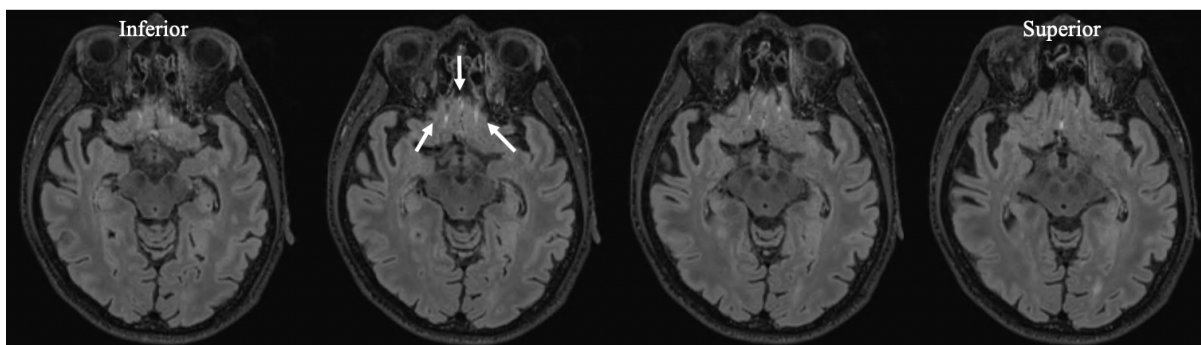
IFSH score 0 (R 0 , M 0, L 0)



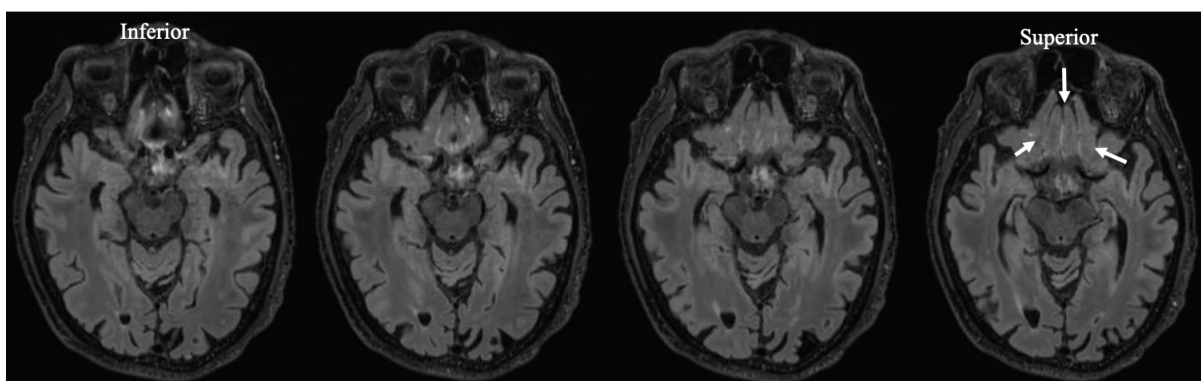
IFSH score 1 (R 0 , M 0, L 1)



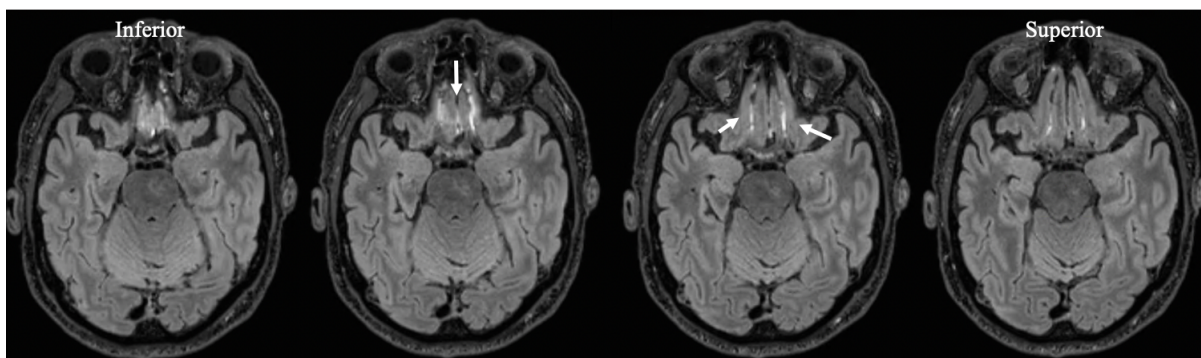
IFSH score 2 (R 1 , M 0, L 1)



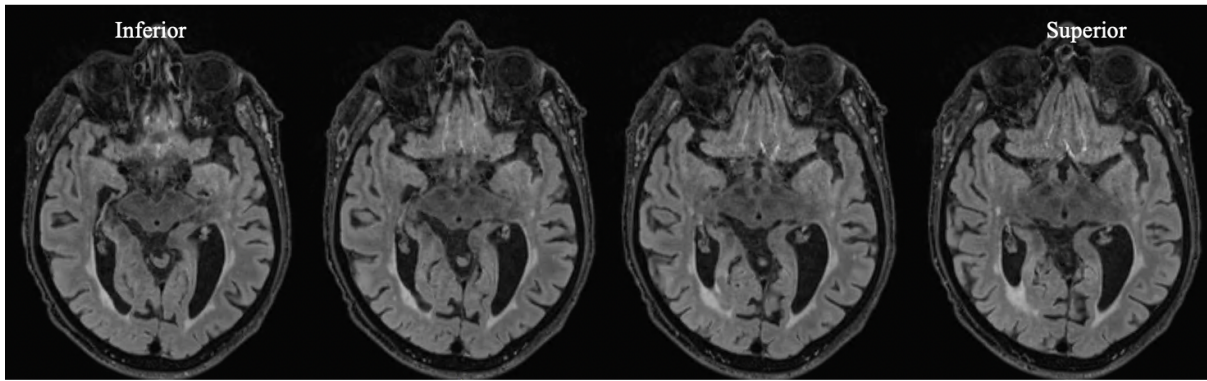
IFSH score 3 (R 1, M 1, L 1)



IFSH score 4 (R 1, M 2, L 1)



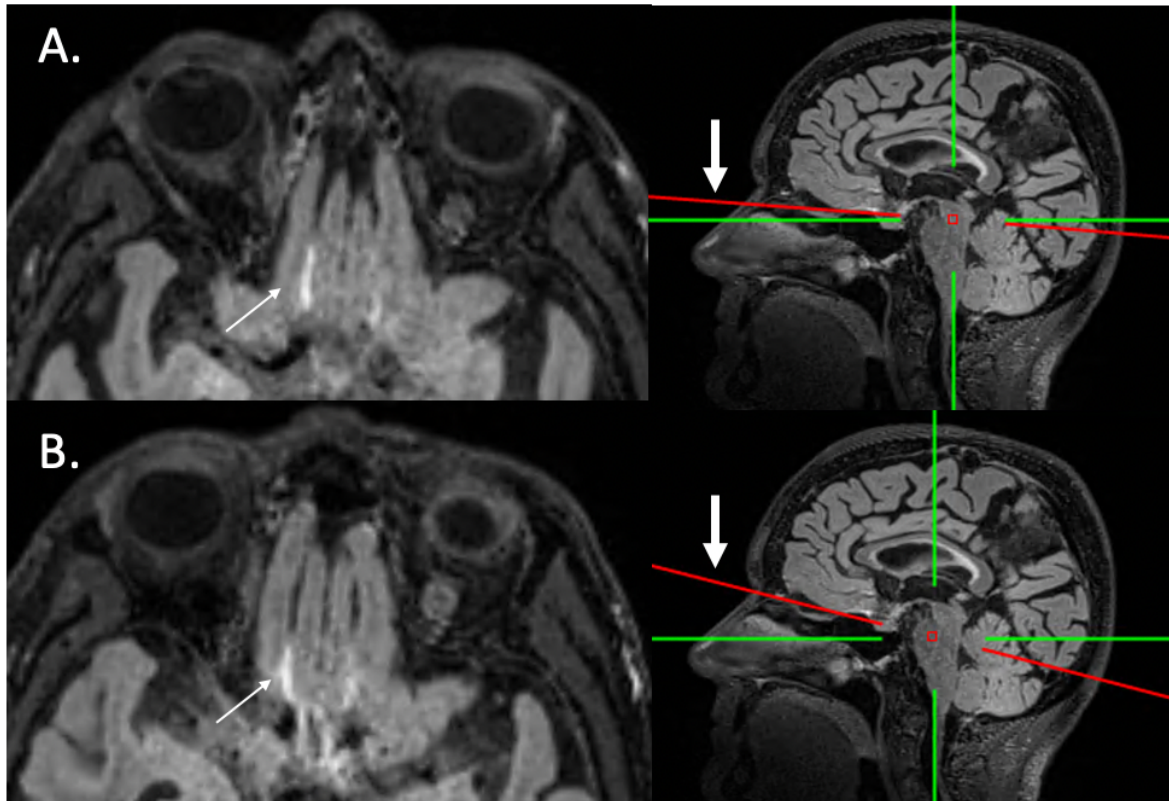
IFSH score 5 (R 2, M 1, L 2)



IFSH score 6 (R 2, M 2, L 2)

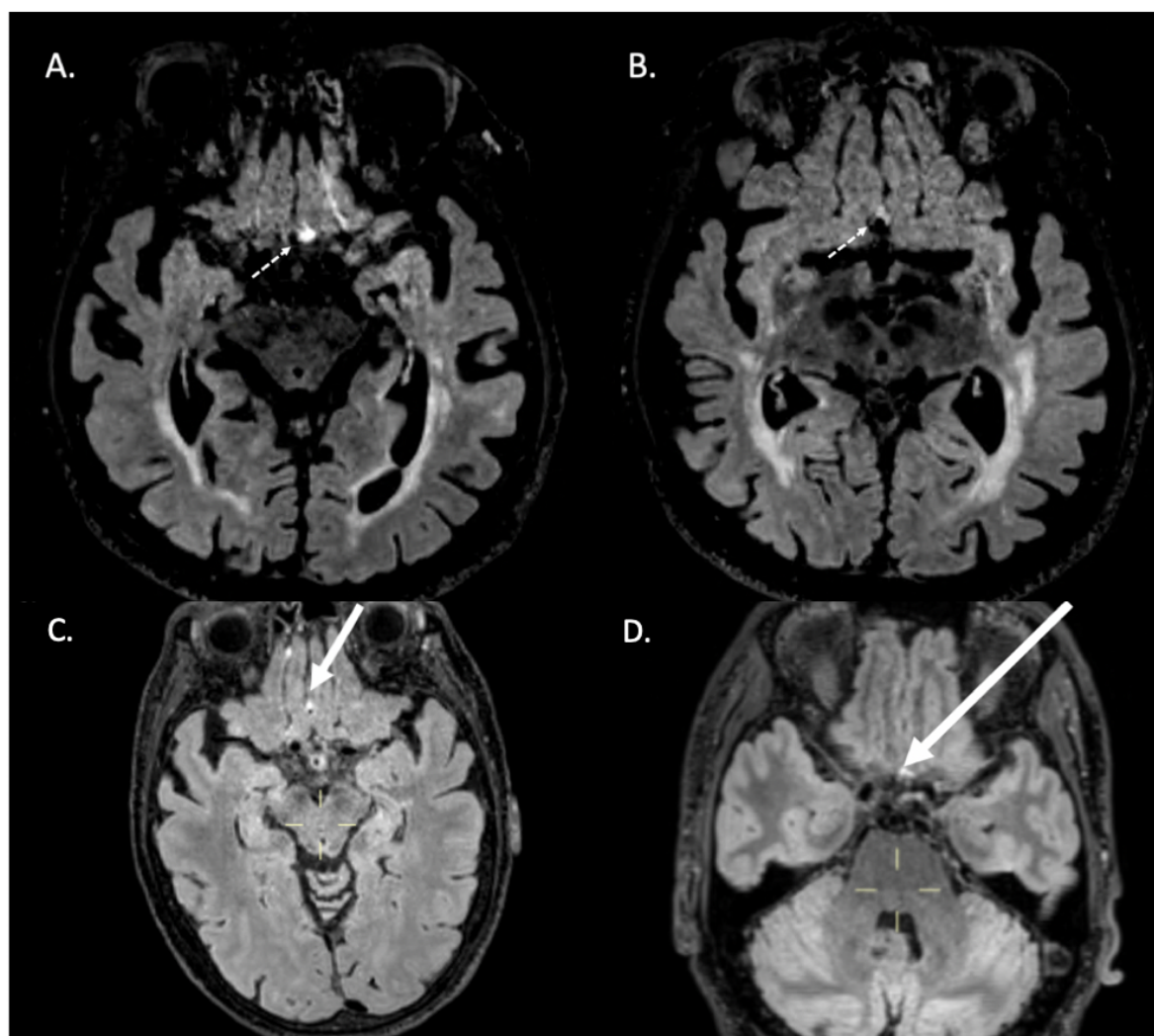
Examples of possible inter-observer variations

Example 1. Different orientation angles in the scan parallel to the floor of anterior cranial fossa in multi-planar reconstruction (MPR) mode.



As we can see, different orientation angles (thick arrow) will result in different extent of IFSH/sulcal involvement (thin arrow). For better view of the inferior frontal sulci, we recommend using angle displayed in A.

Example 2. Artefacts in the middle sulcus.



The above diagrams show some common artefacts in the middle sulcus during rating.

Certain scans (eg, figure A, D) demonstrate a single focus of hyperintensity in the posterior aspect of the middle sulcus, which appears to be related to artefacts from adjacent hyperintensities from the optic chiasm.

A small focus of hyperintensity around a blood vessel (e.g., figure B, C) in middle sulcus is occasionally demonstrated and is felt to represent artefact related to the presence of blood vessel.

In the above 2 scenarios, we regarded those hyperintensities as artefacts and did not take them into account for the scoring of IFSH. The IFSH is considered to be in the inferior frontal sulci and just above the cribriform plate specifically.

Conclusions

The IFSH scale aims to rate objectively and reproducibly the amount of hyperintensity demonstrated in the CSF in the inferior frontal sulci of the brain. By doing so, this allows further analysis to understand the associations and clinical implications of this finding. Further testing of the IFSH scale by other observers will be beneficial in improving its utility and validity.