How to interpret an unenhanced CT brain scan. Part 2: Clinical cases

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Introduction

The aim of this article is to illustrate common pathological findings involving the brain encountered in every day practice. This builds upon our first article titled "How to interpret an unenhanced CT Brain scan. Part 1: Basic principles of Computed Tomography and relevant neuroanatomy" [1].

Case 1

A 70-year old patient presented following a fall and was found on the floor by carers. The patient had no recollection of the event (Figures 1-2).

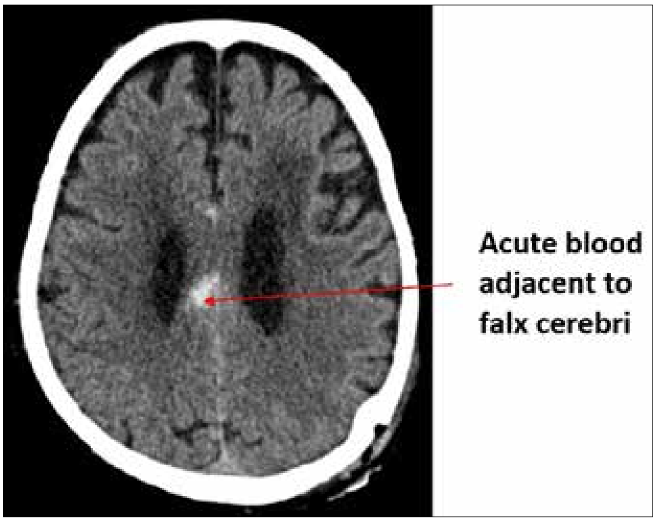

Figure 1 demonstrates a small right sided hyperdensity adjacent to the falx cerebri consistent with an acute intracerebral bleed.

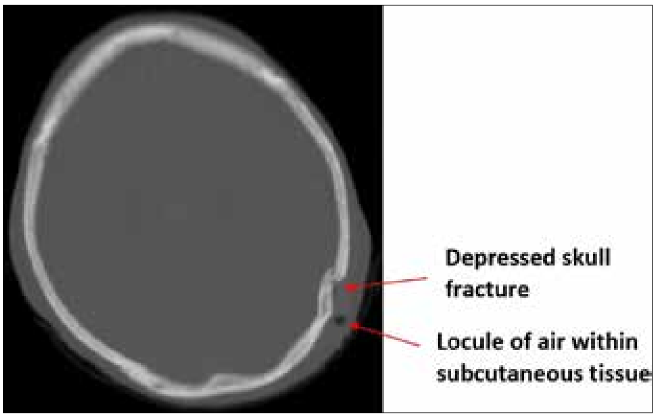

Figure 2. On reviewing the bone windows, a depressed fracture of the left parietal bone is noted. A locule of air is also noted within the subcutaneous tissues consistent with injury to the skin.

Learning points

- On CT, acute blood is displayed as a high Hounsfield unit (HU) and therefore appears bright on the displayed CT image [1]. With time, as the blood products start to break down, the HU of blood decreases and therefore appears darker on the displayed CT image.
- This case illustrates the importance of reviewing all available windows to help recognise pathology.
- In trauma, it is particularly important to review the bone windows to exclude a skull vault fracture [2,]. In this case, had the bone windows not been reviewed, the depressed skull fracture may not have been identified.
- The locule of air noted within the subcutaneous tissues overlying the skull fracture is a further clue that the subcutaneous tissues have been injured due to trauma, allowing air to track under the tissues.

Case 2

A 65-year old male patient presented with acute onset dysarthria and right sided weakness (Figures 3 and 4).

Learning points

- When the clinical question is as to whether a patient has suffered a stroke, it is important to note that in the hyperacute phase (i.e. <3 hours from symptom onset), a normal CT head does not necessarily rule out a stroke [4].
- In the hyperacute phase of stroke, although changes within the brain parenchyma may be happening at the cellular level, the patient may have been scanned at such an early stage that these changes may not yet be identified on CT. Knowing this is critical as a negative CT head in a patient with clinical signs and symptoms of a stroke may otherwise be falsely reassuring.

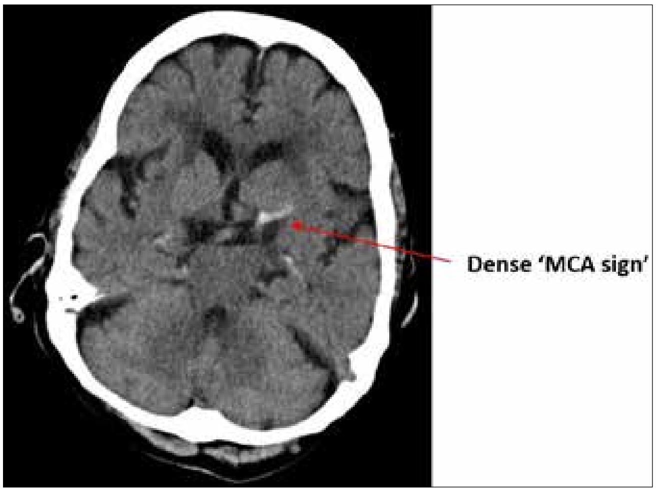

Figure 3. Unenhanced CT head demonstrating a hyperdense left middle cerebral artery (MCA) consistent with an acute thrombus within the left MCA. This radiological sign is known as the 'dense MCA sign'.

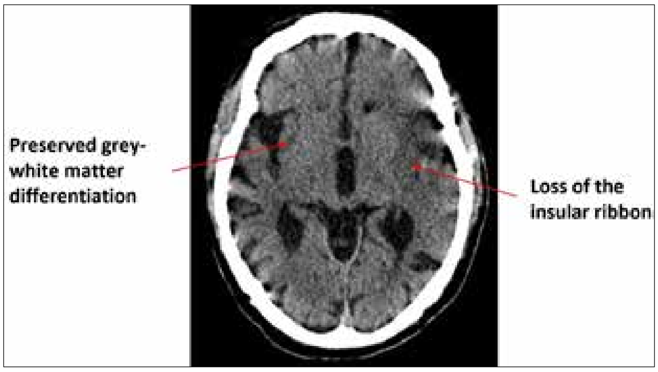

Figure 4. Subtle loss of grey-white matter interface in the region of the left lateral margin of the insular cortex.

- In the early phases of stroke, the main role of a CT head is to exclude an intra- or extra-axial haemorrhage or mass lesion within the brain [3]. In the acute phase, the clinical team can then decide whether the patient should undergo thrombolytic therapy.
- Some early features to look for which may be suggestive of tissue infarction are:
  - ''Loss of the insular ribbon sign''. This refers to loss of the normal grey-white matter differentiation in the region of the insular cortex on the affected side. The insular cortex is particularly vulnerable to ischaemia due to poor collateral blood flow in this region.
  - Hypoattenuation (reduced density/darker) of the caudate nucleus on the affected side. This is due to reduced perfusion of the caudate nucleus which typically gets its blood supply from the lenticuostriate vessels (i.e. deep perforating branches of the middle cerebral artery) [2, 4].
  - Acute hyperdense thrombus within one of the major cerebral arterial vessels of the circle of Willis (Figure 4).

Case 3

A 65-year old male presented with acute onset left sided weakness (Figures 5, 6 and 7).

Learning points

- Major arterial infarcts involve both the grey and white matter and tend to be wedge shaped in appearance.
- Irrespective of the underlying aetiology of a stroke, the end result is the same - brain parenchyma is affected

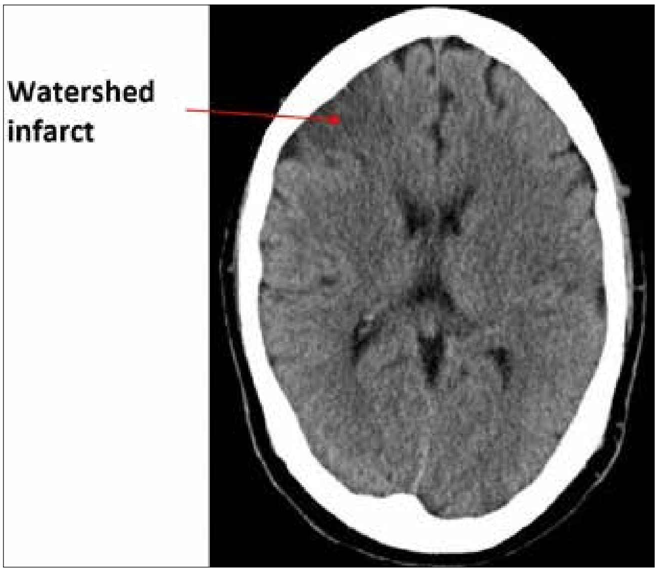

Figure 5. A watershed infarct is demonstrated between the anterior- and middle-cerebral artery territories.

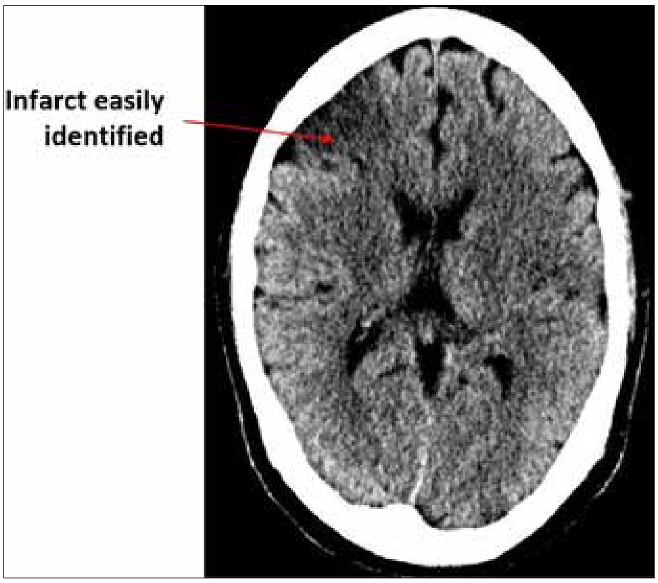

Figure 6. The same area of ischaemia is demonstrated more clearly on a stroke window.

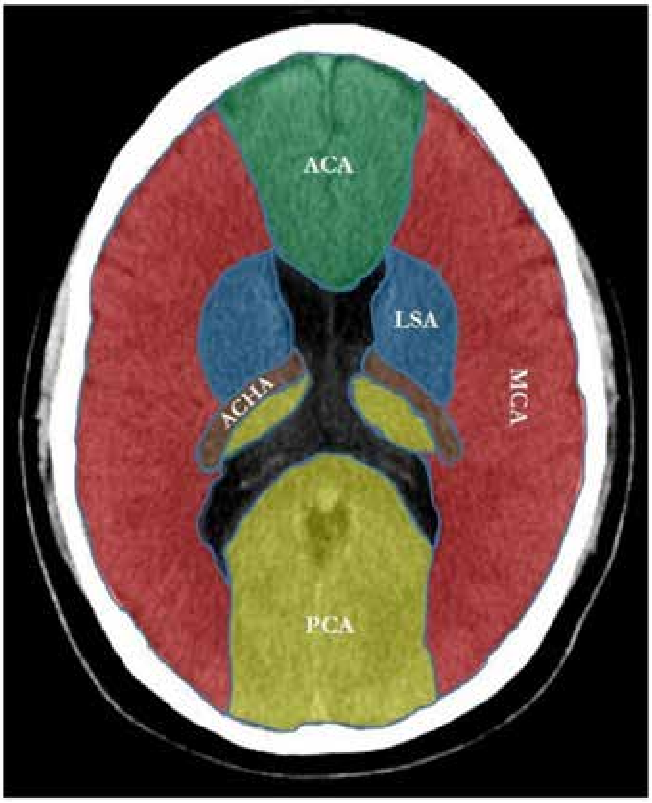

Figure 7 demonstrates the main cerebral vascular territories. ACA, anterior cerebral artery; MCA, middle cerebral artery; PCA, posterior cerebral artery; LSA, lenticulostriate arteries; ACHA, anterior choroidal artery. (Created by Dr Thomas Osborne, Radiology registrar at Ashford and St Peter's NHS Foundation Trust).

by a process known as cytotoxic cell death. This is reflected by a loss of the normal grey-white matter differentiation in the region of the infarct.

- As illustrated in this case, watershed infarcts occur between cerebral vascular territories with no or little anastomoses.
- By changing the window settings to a dedicated stroke window (e.g. HU of window width of 40 and window width of 40) helps aid the visualisation of subtle losses in grey-white matter differentiation [2-4].

Case 4

A 70-year old female with hypertension presented with confusion (Figure 8).

Learning points

- High density material on a CT Brain study may include:
  - Acute blood.
  - Calcification.
  - Intravenous contrast.

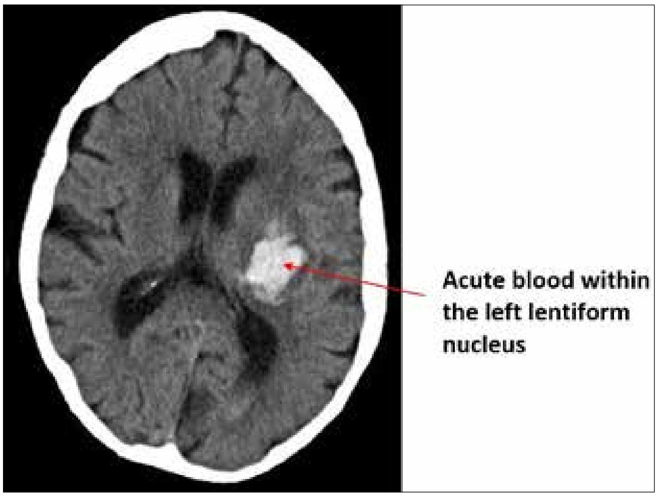

Figure 8 demonstrates an acute bleed within the left lentiform nucleus.

- In the context of a non-traumatic bleed, the following should be considered as possible underlying causes:
  - Hypertensive bleed.
  - Haemorrhagic transformation of an infarct.
  - Haemorrhagic mass (primary or secondary lesion).
- Both the clinical context (such as the presence of cardiovascular risk factors, previous malignancy etc) and the location of the bleed seen on CT can help to identify the underlying cause for the bleed.
- For example, hypertensive bleeds typically affect the basal ganglia. The other common locations for hypertensive bleeds include:
  - 80% lenticulostriate.
  - 10% pons.
  - 10% cerebellum [3, 4].

Case 5

A 35-year old male presented with a sudden onset occipital headache (severity 10/10) and vomiting (Figure 9).

Learning points

- The common causes of a subarachnoid haemorrhage include rupture of an intracerebral aneurysm and trauma.
- Blood accumulates in the following subarachnoid spaces:
  - Sylvian fissure.
  - Basal cisterns.
  - Overlying sulci and surface of the tentorium cerebelli.

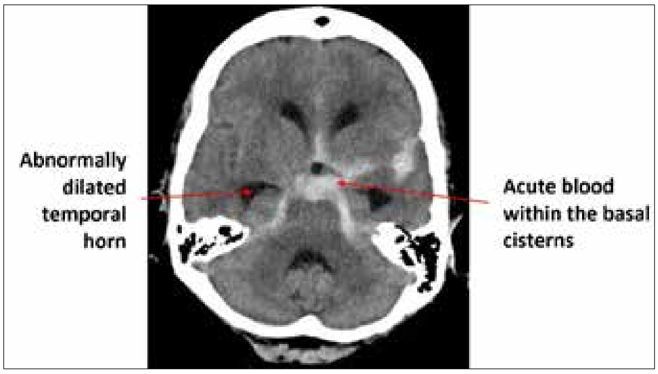

Figure 9 demonstrates acute blood within the basal cisterns consistent with an acute subarachnoid haemorrhage.

- The accumulation of blood within the subarachnoid space may result in the development of hydrocephalus [3, 4].
- As demonstrated in this case, one of the earliest signs suggestive of an evolving hydrocephalus is dilation of the temporal horns of the lateral ventricles.
- If a subarachnoid haemorrhage is confirmed, further investigations should be performed to identify and treat the underlying cause. Investigations may include a CT angiogram or formal angiogram.
- CT has a >95% sensitivity for identifying a subarachnoid haemorrhage within the first 12 hours. The sensitivity declines to 80% after 12 hours [2, 3].
- In the presence of a normal CT Brain study, a lumbar puncture should be performed to exclude a small subarachnoid haemorrhage.

Case 6

A 60-year old alcoholic male presented with worsening confusion over the past month following a fall (Figure 10).

Learning points

- Subdural haematomas are extra-axial collections of blood within the subdural space.
- This results in a crescentic configuration of the subdural haematoma.
- Blood is confined within the subdural space and is therefore unable to cross dural attachments but can cross bone sutures [3, 4].
- To reiterate, acute blood appears bright on CT and becomes darker over time (Figure 10).
- Figure 10 demonstrates a subdural collection of mixed density material which represents both acute and chronic blood products. This therefore suggests that the patient has sustained an acute bleed on a background of a pre-existing haemorrhage.

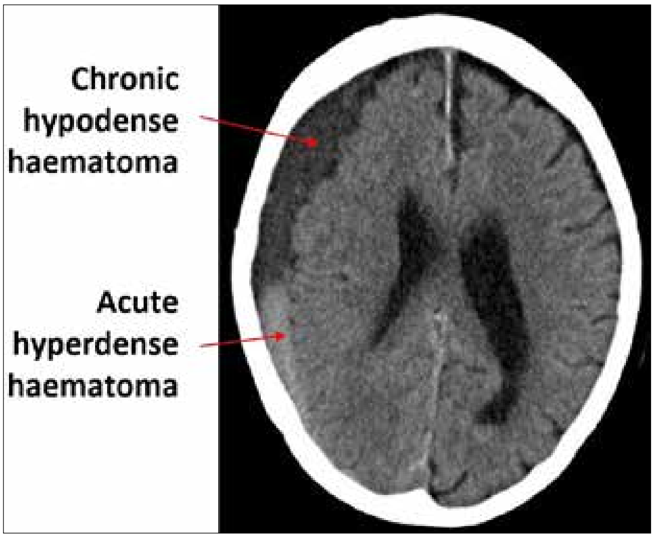

Figure 10 demonstrates an acute-on-chronic right sided frontoparietal subdural haematoma.

- Although an underlying bone fracture was not identified in this case, this is important to exclude by looking at the bone windows.

Case 7

A 70-year old female presented following a fall. A non-ST elevation myocardial infarction was demonstrated on her electrocardiogram. She underwent an urgent CT head to exclude an intracranial bleed prior to commencing antiplatelet therapy (Figure 11).

Learning points

- Although an intracranial bleed was not demonstrated, locules of free intracranial gas were noted at the base of the skull.
- This case again illustrated the importance of viewing all available windows to help exclude pathology. By changing the window setting to lung windows on the same axial slice, intracranial air becomes easier to appreciate.
- In the context of trauma, although an underlying fracture was not identified in this case, the presence of intracranial air raises the suspicion of a base of skull fracture.
- Other helpful clues which can help raise the suspicion of a base of skull fracture include a fluid level within the sphenoid sinuses and clinical signs i.e. CSF rhinorrhea and otorrhea, mastoid ecchymosis (Battle sign) and periorbital ecchymosis (Raccoon eyes) [4].

Case 8

A 45-year old presented with tonic-clonic seizures following a fall (Figures 12-15).

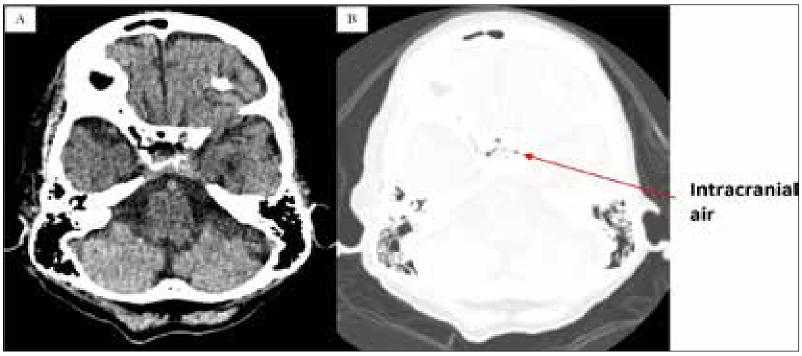

Figure 11. Locules of intracranial air are easily overlooked on Figure 11A on the default brain windows. These are more easily identified on Figure 11B when the settings are changed to lung windows.

Learning points

- In the context of trauma, it is important to identify signs indicative of raised intra-cranial pressure (ICP).
- Raised ICP can lead to 'mass effect' which refers to the distortion of the size and/or position of normal brain structures when they are displaced by an abnormal structure e.g. intracerebral mass or intra- or extra-cranial bleed.
- CT features of raised intracranial pressure include:
- Displacement of midline structures towards the opposite side of the primary intracranial pathology.

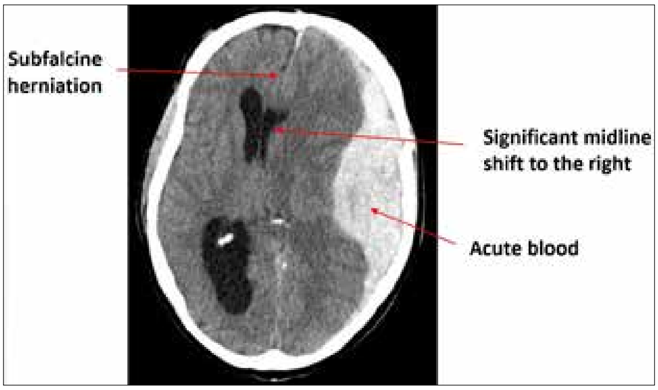

Figure 12 demonstrates a large left-sided acute subdural haematoma. There is significant shift of the midline structures to the right with partial compression of the left lateral ventricle and subfalcine herniation seen to the right.

- Loss of sulci and gyri.
- Various forms of parenchymal herniation including subfalcine, transtentorial and tonsillar herniation (Figure 14).
- It is important to note that a CT study can be used to look for a possible structural cause for the patient's signs and symptoms, however a CT study should not be used to exclude raised ICP.

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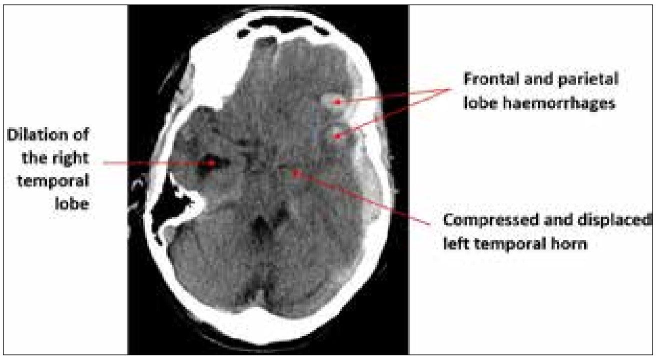

Figure 13 demonstrates near total effacement of the left temporal horn with dilatation of the right temporal horn in keeping with an evolving hydrocephalus. Two further foci of intra-parenchymal haemorrhage are seen within the left frontal and parietal lobes.

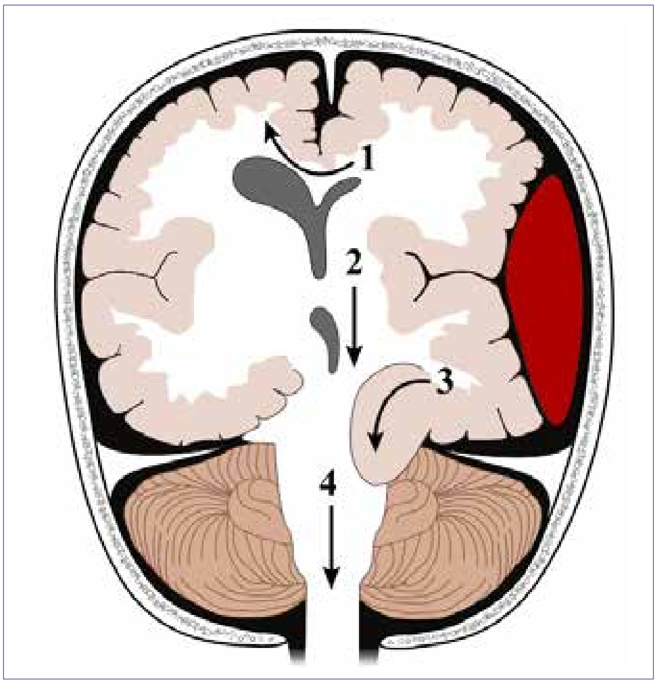

Figure 14 demonstrates four common types of brain herniation secondary to a left extradural haematoma 1. Subfalcine 2. Central 3. Transtentorial 4. Tonsillar. Image obtained from Wikipedia [6].

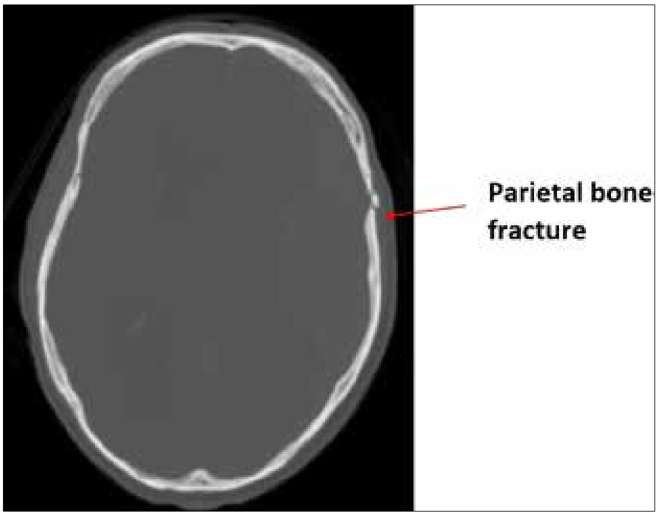

Figure 15 demonstrates a fracture of the left parietal bone on the bone window setting.

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