Neuroimaging, head and neck imaging

Imaging methods

Conventional radiography

With the development of modern imaging diagnostic techniques, such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI), the importance and usefulness of skull radiography has gradually decreased. However, the speed of the examination can prove useful in certain situations such as:

- inflammatory sinus disorders (opacification of paranasal sinuses because of fluid accumulation);
- traumatic pathology (can detect skull fractures and opacification of paranasal sinuses because of fluid accumulation)
- tumor pathology (osteosclerotic or osteolytic changes in cranial bone structures in case of secondary lesions or in case of multiple myeloma);
- changes of the sella turcica;
- presence of intracranial calcifications developed in the brain parenchyma, choroid plexus and/or pineal gland.

Imaging methods

Conventional radiography

A cranium X-ray must include at least two incidences (frontal + profile image). Depending on the examined region, several specific incidences can be used.

The spine investigation using conventional radiography is usually performed in frontal + profile incidence and, in some cases, in oblique incidence.

Imaging methods

Conventional radiography

An X-ray of the spine performed in the frontal incidence allows examination of:

- vertebral bodies;
- transverse apophyses;
- vertebral spinous processes;
- scoliosis.

An X-ray of the spine performed in the profile incidence allows examination:

- vertebral bodies;
- vertebral spinous processes;
- vertebral pedicles;
- the intervertebral space;
- kyphosis / lordosis.

Imaging methods

Conventional radiography

The radiological examination of the spine is useful in evaluating the following pathological changes:

- detection and characterization of the osteosclerotic / osteolytic lesions that affect the vertebral bodies;
- the presence / absence of listhesis;
- the presence / absence of scoliotic changes;
- the accentuation / deletion of the kyphotic / lordotic modifications;
- detection and characterization of congenital anomalies (spina bifida);
- presence / absence of osteophytes, syndesmophytes;
- spinal canal calibre changes.

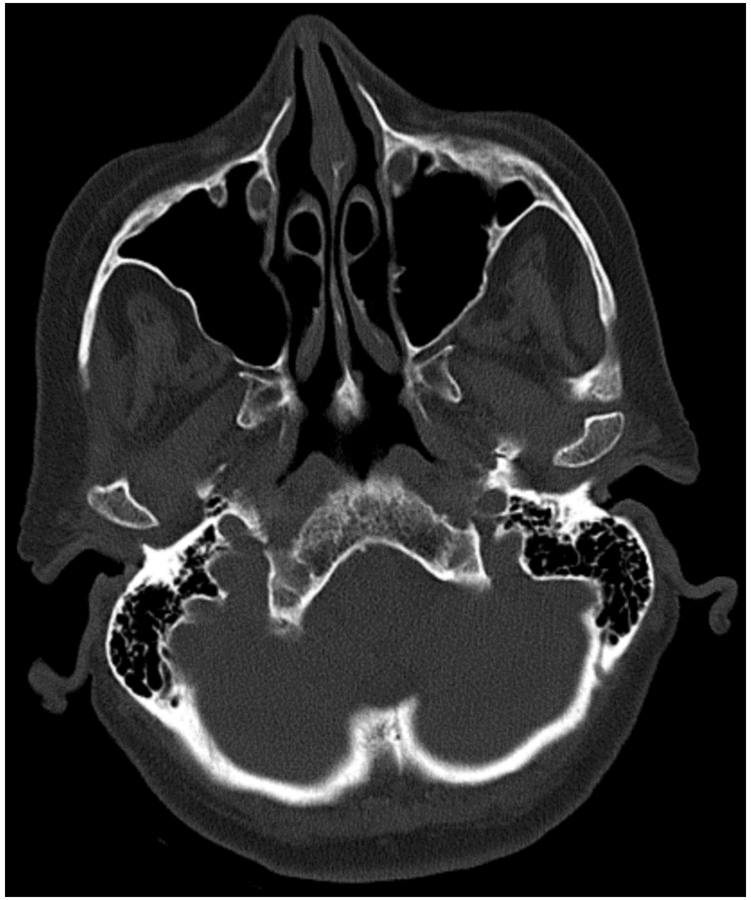
Imaging methods

Computed Tomography (CT)

The main indications for a cranial CT examination are:

- **vascular pathology** (ischemic strokes, hemorrhagic strokes);
- **traumatic pathology** (CT examination is ideal for polytraumatic patients who cannot be immobilized for a long time);
- **tumor pathology** (most often it requires administration of a iodinated contrast agent to highlight the primitive or secondary tumor lesions);
- **infectious pathology** (eg, brain abscess);
- **cranio-cerebral malformations.**

Imaging methods



Normal head CT

Imaging methods

Computed Tomography (CT)

The main indications of the CT examination of the spine are:

- **tumor pathology** (primary or secondary bone tumors);
- **traumatic pathology** (fractured and collapsed vertebral bodies, posterior wall bulging inside the medullary canal, hyperdensities in the medullary cord);
- **malformative pathology** (spina bifida);
- **degenerative pathology** (presence of osteophytes, intraspongial hernias, intervertebral spaces with reduced height).

Imaging methods

Magnetic Resonance Imaging (MRI)

The main indications of the cranial MRI exam are:

- vascular pathology (MRI examination can detect, through DWI diffusion sequences, an ischemic stroke in the first six hours from the moment it produced, when CT changes are still undetectable; MRI examination can be extremely useful in the evaluation of vascular malformations such as cavernoma; moreover, in case of cerebral aneurysms, the MRI examination performed with angio sequences allows detection and characterization of these lesions with a high accuracy);

- tumor pathology (in this case, it is necessary to administer a paramagnetic contrast agent in order to be able to locate and determine the benign or malignant character of the lesion);

- **demyelinating diseases** (MRI is considered the examination of choice for the assessment of the demyelinating diseases such as multiple sclerosis, when the FLAIR sequence is extremely useful in accurately detecting and locating the demyelinating lesions; using paramagnetic contrast agent in patients with multiple sclerosis can establish if the lesions are active (they enhance contrast) or if they are inactive (they do not enhance contrast);

Imaging methods

Magnetic Resonance Imaging (MRI)

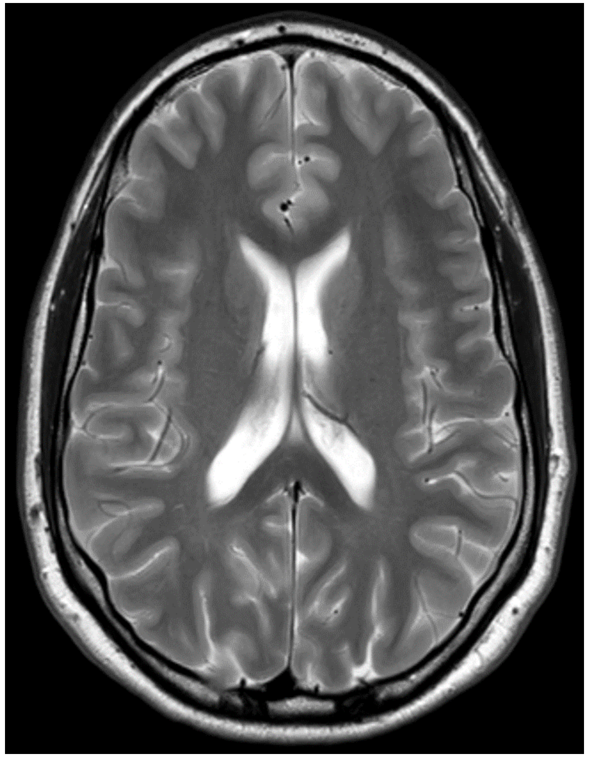
- infectious pathology (the MRI examination is preferred in order to establish the imaging diagnosis of meningitis or encephalitis);

- pituitary gland pathology (the MRI examination is considered of choice when it comes to detection the pathological changes that affect the pituitary gland);

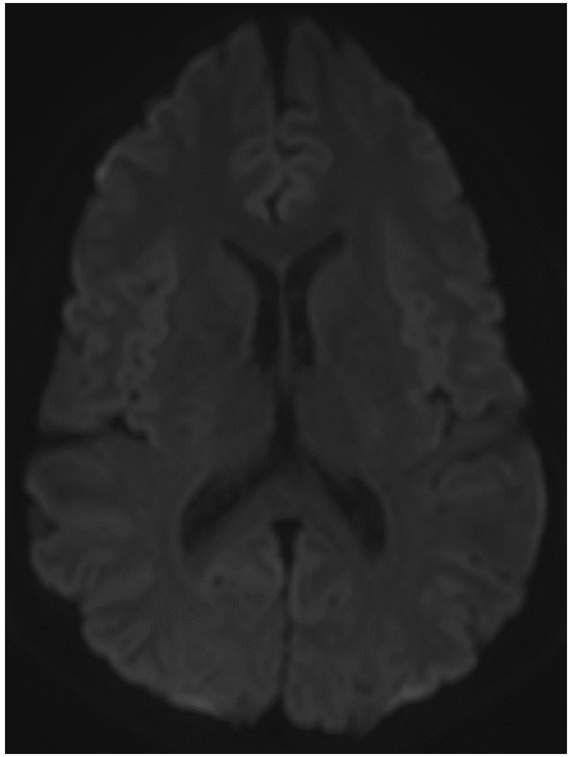
- pathology of the ponto-cerebellar angles (the MRI examination is far superior to the CT examination in order to detect tumoral processes developed inside the internal ear or cranial nerves - for example, acoustic neurinoma);

- malignant cranio-cerebral pathology.

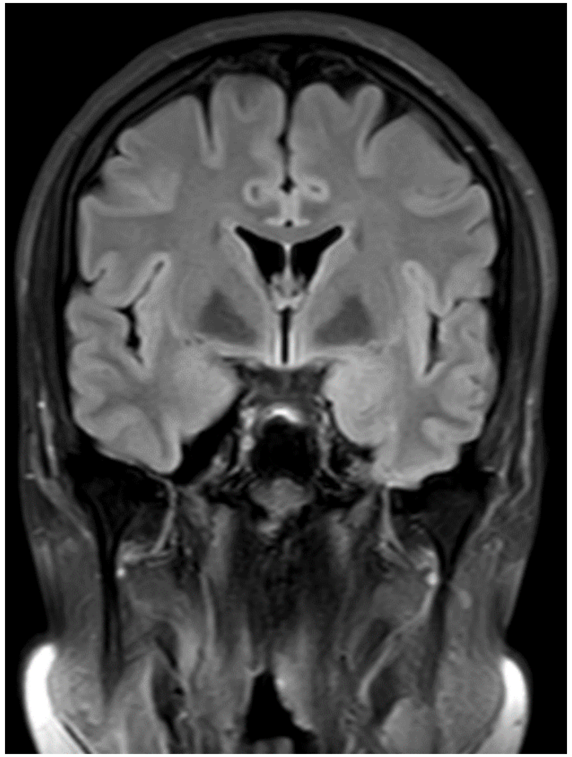
Imaging methods



T2



DWI



FLAIR

Imaging methods

Magnetic Resonance Imaging (MRI)

The main indications of the MRI examination of the spine are:

- degenerative pathology (can detect Modic I - bone edema, Modic II - lipomatous degeneration and Modic III type changes - osteosclerosis; this examination can also detect the intraspongial hernias, listhesis, osteophytes and degenerative changes of the intervertebral discs; moreover, disc hernias or protrusions that compress the medullary cord or the nerve roots can be seen);

- traumatic pathology (the MRI can detect spinal contusion and epidural hematoma);

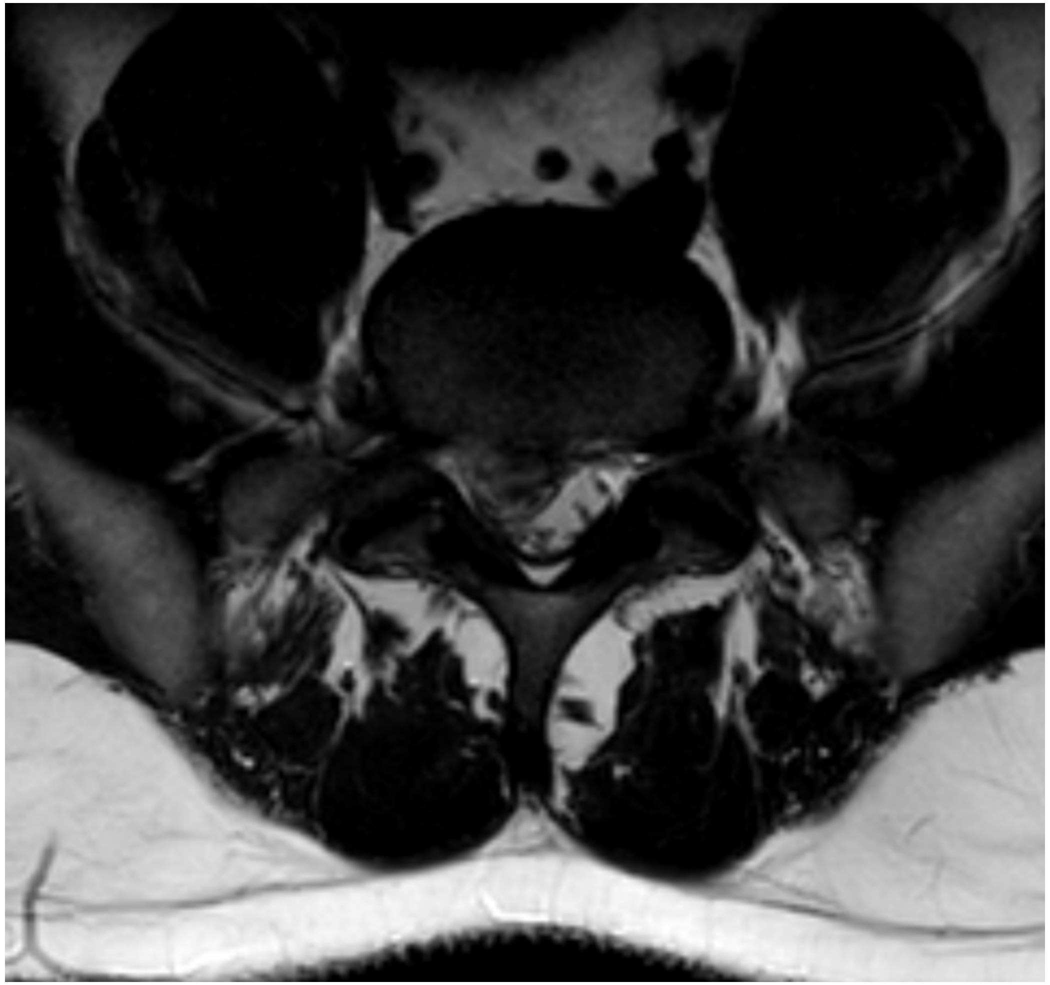
- tumor pathology (by administering a paramagnetic contrast agent, the MRI examination is able to locate and accurately characterize the benign and malignant nature of the tumor lesions that affect the spinal cord or vertebral bodies, as well as their extension to the adjacent structures);

- inflammatory-infectious pathology (the MRI can detect spondylodiscitis, paravertebral abscesses and extension in the soft paravertebral tissues);

- malformative pathology.

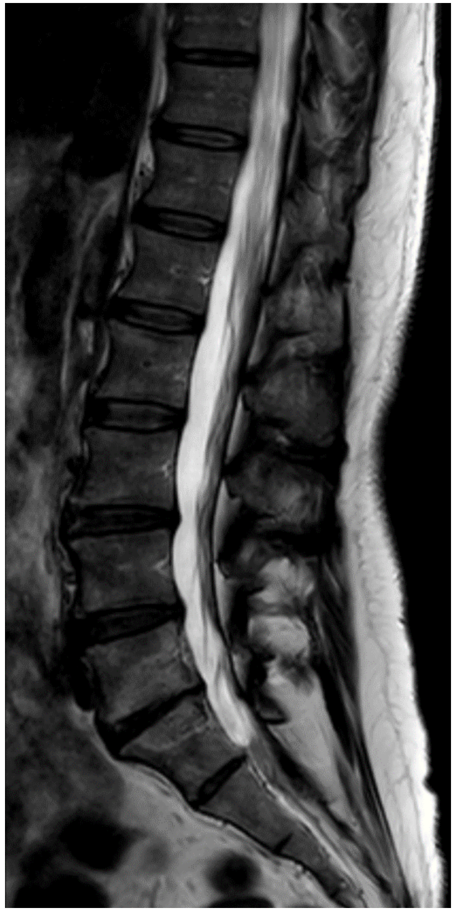
Imaging methods

Magnetic Resonance Imaging (MRI) – disc herniation + fragment + migration



Imaging methods

Magnetic Resonance Imaging (MRI) – L5-S1 bone edema



Imaging methods

Magnetic Resonance Imaging (MRI) – Modic II changes L3 and L4-L5

Imaging methods

Magnetic Resonance Imaging (MRI)

Imaging methods

Magnetic Resonance Imaging (MRI) - spondylodiscitis

Brain pathology

Ischemic stroke

Ischemic stroke (stroke) occurs as a result of stopping the nutritional blood supply to the cerebral parenchyma due to thrombi, atherosclerotic emboli, arterial spasm or metabolic disorders. A large caliber artery (anterior, middle or posterior cerebral artery) or smaller caliber segmental branches may be affected. It is important to note that an ischemic stroke can become hemorrhagic.

Ischemic stroke classification according to the time elapsed from the initial moment is performed as follows:

- hyperacute (under 24 hours);

- acute (24 hours - 7 days);

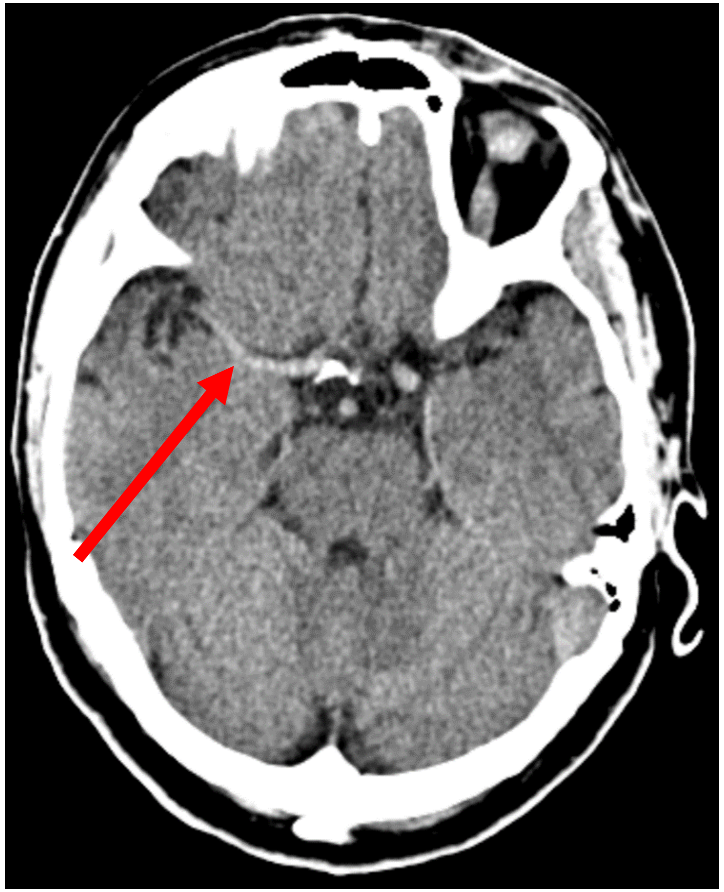
- subacute (1 - 3 weeks);

- chronic (over 3 weeks).

Brain pathology

Hyperacute ischemic stroke

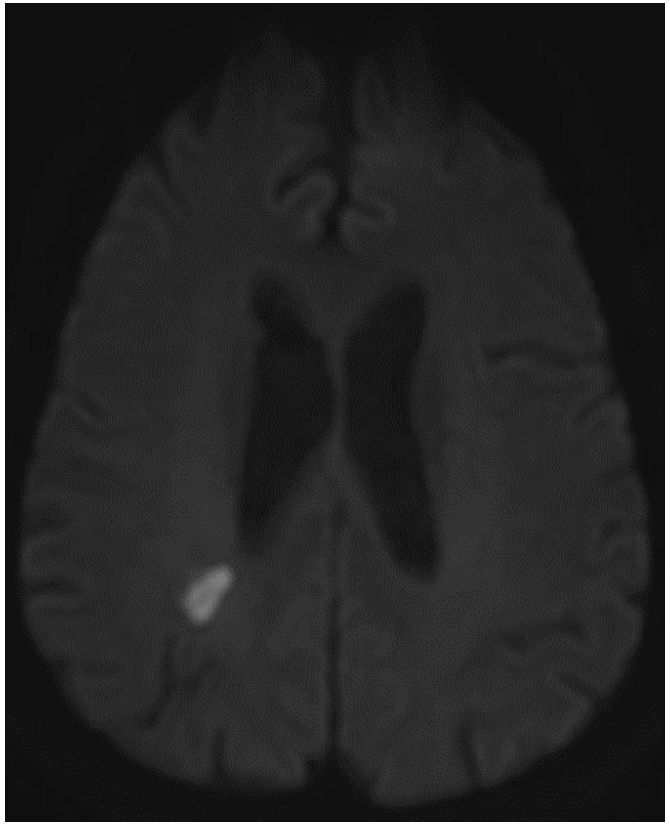
In the hyperacute stage, the first detectable sign when examining CT without contrast agent injection is the hyperdensity of the affected cerebral artery due to the presence of intravascular thrombus at this level. Most commonly, the middle cerebral artery is affected.



Brain pathology

Hyperacute ischemic stroke

Within a few minutes, the MRI exam is able to detect the affected area using diffusion sequences (DWI) and the ADC map. A hyperacute ischemic stroke can be detected using MRI as an intense hypersignal in DWI and hyposignal in the ADC map. The lack of the flow signal visualization in the affected vessel in the angio sequences allows a proper localization of the obstruction caused by an intraluminal thrombus. After about 6 hours, the signal intensity becomes higher in T2 and FLAIR sequences. Also, at about 16 hours from the initial moment, the infarcted brain parenchyma appears as hypointense T1.



Brain pathology

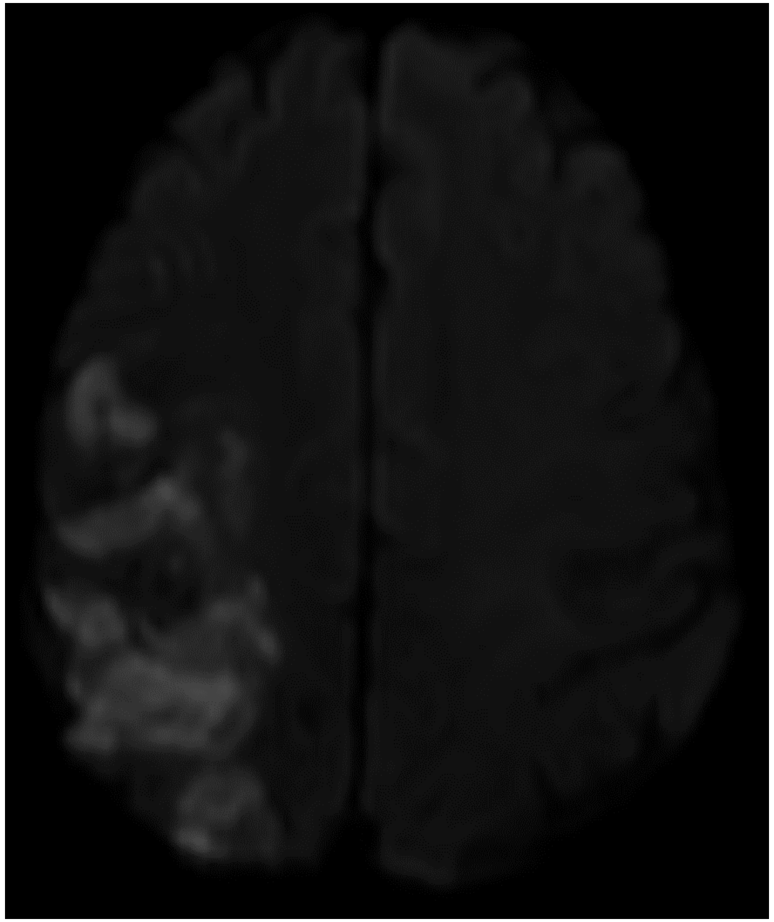
Acute ischemic stroke

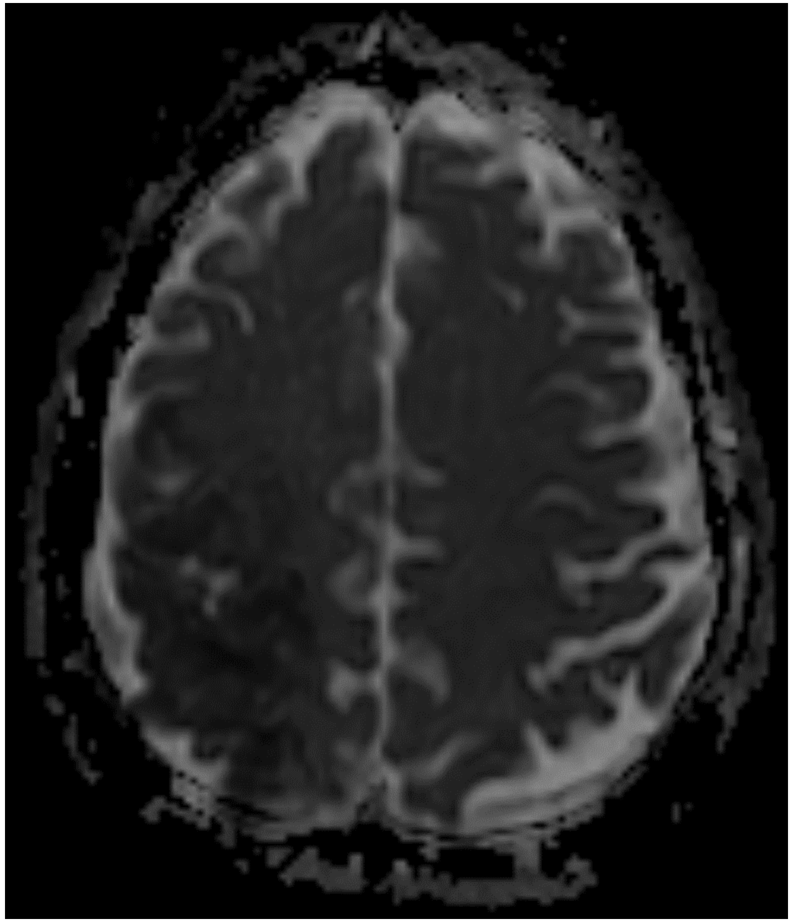
Starting from the acute stage, the changes become more evident on the CT examination in the form of a hypodense area, with fading of the brain gyruses and mass effect manifested over the adjacent cerebral parenchyma and / or over the ventricular system, in the context of edematous changes developed at this level.

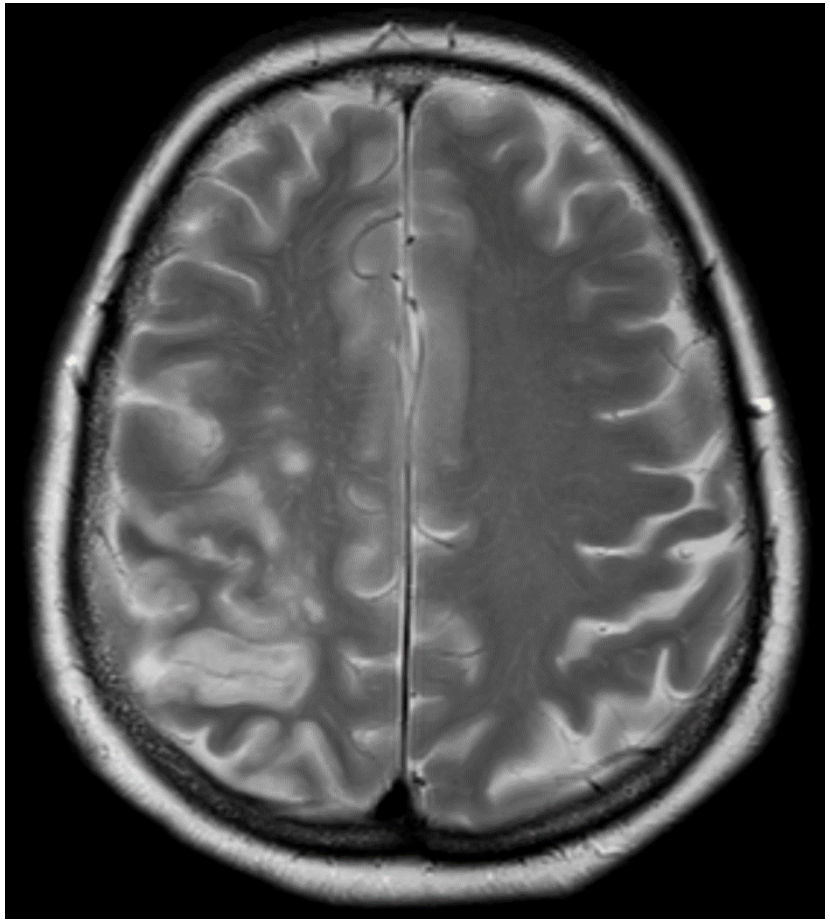
By the end of the first week, the infarcted brain parenchyma appears as hypersignal in the DWI sequence and hyposignal in the ADC map. The signal of the affected area remains increased in the T2 and FLAIR sequences and low in the T1 sequence.

Brain pathology

Acute ischemic stroke







Brain pathology

Subacute ischemic stroke

In the subacute stage, the CT examination may have a misleading appearance, as the subacute stroke area may look very similar to that of the healthy adjacent cerebral parenchyma. Note the reduction in intensity of the edematous changes and of the mass effect on the cerebral parenchyma and / or ventricular system. In the MRI exam, the signal strength is increased in the DWI sequence, but the signal in the ADC map starts to increase. In this phase, the signal intensity in the T1 sequence remains low and the signal intensity in the T2 and FLAIR sequences remains high.

Brain pathology

Acute/subacute ischemic stroke

Brain pathology

Chronic ischemic stroke

In the chronic stage, the CT examination reveals no edematous changes in the affected cerebral parenchyma. The mass effect generated by the edema described before is replaced in this phase with gliotic changes that tend to retract the adjacent cerebral parenchyma and / or the ventricular system. Brain gliosis is seen as an intensely hypodense area. In MRI, the signal intensity in the DWI sequence decreases but in the ADC map the signal intensity is increased. The gliotic changes appear as hyperintense on T2 and FLAIR and retract the adjacent cerebral parenchyma and / or the ventricular system.

Brain pathology

Hemorrhagic stroke

Most commonly, hemorrhagic stroke occurs as a result of hypertension that exceeds the adaptability limits of the cerebral arterial vascular structures and results in intracerebral hemorrhage.

The classification of hemorrhagic stroke after the time elapsed from the initial moment is performed as follows:

- hyperacute (under 24 hours);

- acute (1 - 2 days);

- subacute (3 - 7 days);

- chronic (over 1 week).

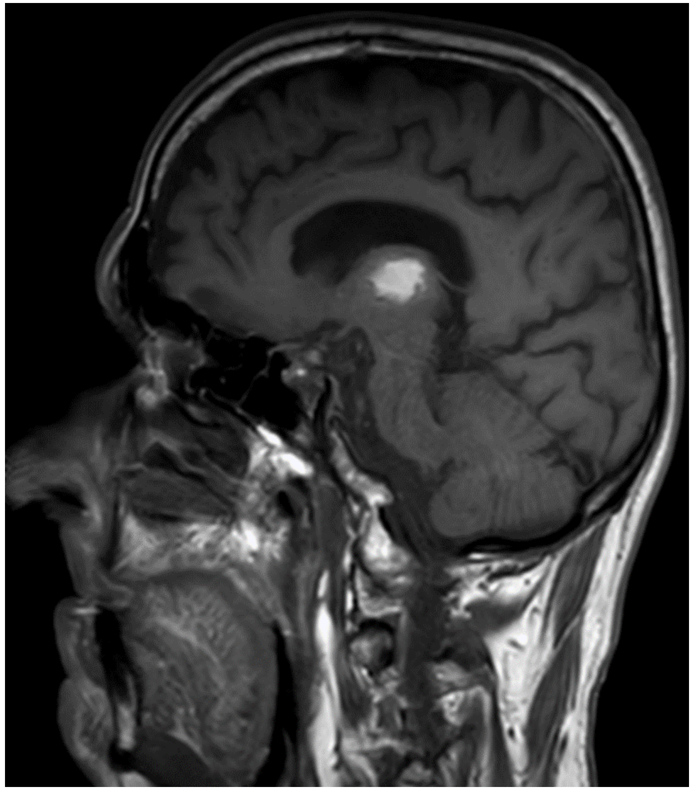
Brain pathology

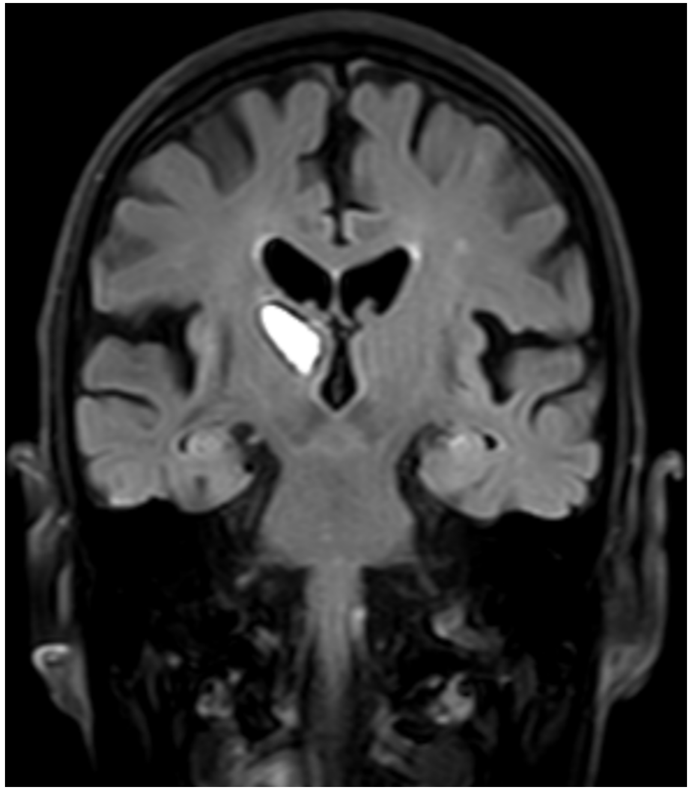
Hemorrhagic stroke

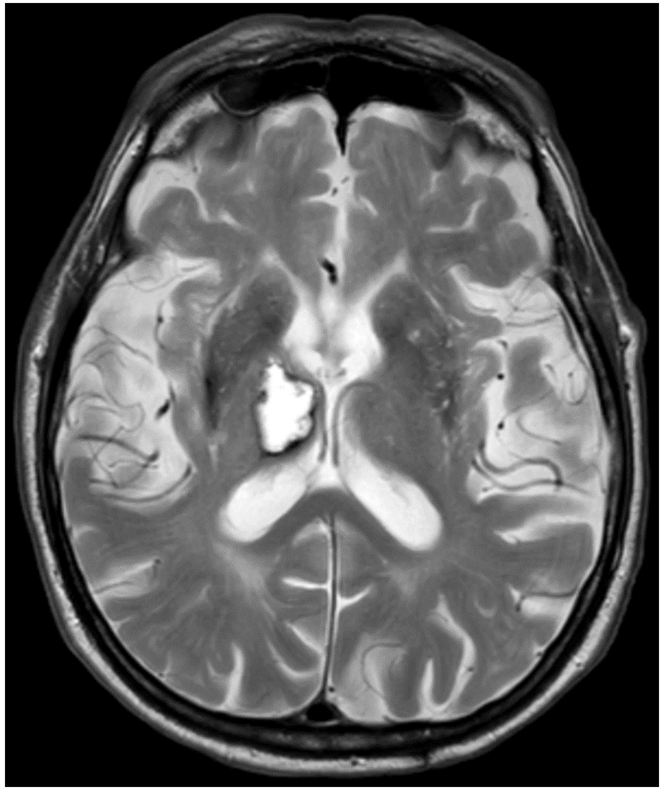
In the acute stage, the CT examination is considered the imaging method of choice in establishing the imaging diagnosis of intraparenchymatous haemorrhage. Blood in the acute stage appears hyperdense to the adjacent cerebral parenchyma and has densities of about 50-70 UH. In the subacute stage, intra-parenchymal hemorrhage is difficult to differentiate from the normal adjacent cerebral parenchyma. In the chronic stage, the intra-parenchymal hemorrhage appears hypodense to the adjacent cerebral parenchyma. It is important to note that the mass effect generated by the blood accumulation over the adjacent cerebral parenchyma and / or the ventricular system is visible in all stages.

Brain pathology

Hemorrhagic stroke



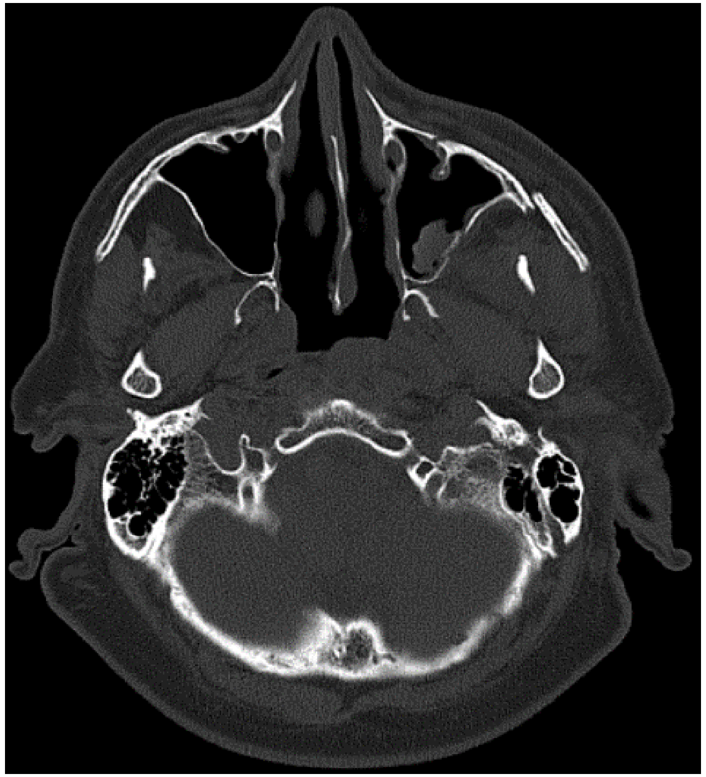




Skull and brain trauma

Fractured skull bones

The fractures of the cranial bones are usually found in case of polytraumatized patients, and the imaging technique of choice in this situation is CT. In case of fractured skull bones, the interruption of the bone continuity is highlighted and, depending on the fracture path, associated changes can be detected (for example, in case of a fracture in the walls of the maxillary sinus, fluid accumulation can be detected inside the affected sinus - hemosinus).



Skull and brain trauma

Brain contusions

Brain contusions frequently occur in young people in a post-traumatic context. The CT examination is the investigation of choice in these patients. Hemorrhagic contusions appear in the form of spontaneous hyperdense areas, surrounded by hypodense adjacent edema. If the contusions are not hemorrhagic (edematous contusions), they are as hypodense areas that become isodense compared to the brain parenchyma within a few weeks, as the edema changes are remitted. In the initial phases, the mass effect on the adjacent cerebral parenchyma is also present.

Skull and brain trauma

Diffuse brain edema

Skull and brain trauma

Subarachnoid haemorrhage (HSA) is best visualized in the acute stage on CT examination as hyperdense accumulations in the subarachnoid space.

Subdural hematoma

The subdural hematoma appears in the form of a semilunar blood accumulation with a density that varies according to the time elapsed from the moment of production:

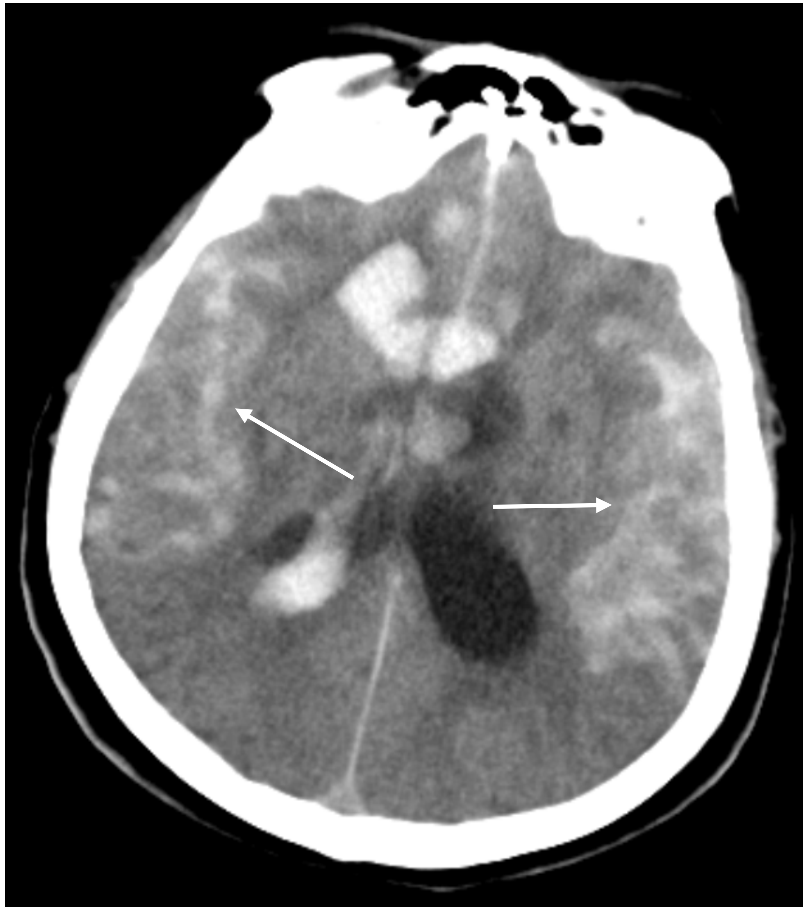
- ***in the acute stage***, hyperdense compared to the adjacent cerebral parenchyma;
- ***in the subacute stage***, isodens relative to the adjacent cerebral parenchyma;
- ***in the chronic stage***, hypodense relative to the adjacent cerebral parenchyma.

Epidural hematoma

The epidural hematoma appears in the form of a biconvex blood accumulation with a density that varies according to the time elapsed from the moment of production:

- ***in the acute stage***, hyperdense compared to the adjacent cerebral parenchyma;
- ***in the subacute stage***, isodense relative to the adjacent cerebral parenchyma;
- ***in the chronic stage***, hypodense to the adjacent cerebral parenchyma.

Skull and brain trauma



Subarachnoid hemorrhage

Skull and brain trauma

Bilateral frontal cerebral laceration

Skull and brain trauma

Acute subdural hematoma

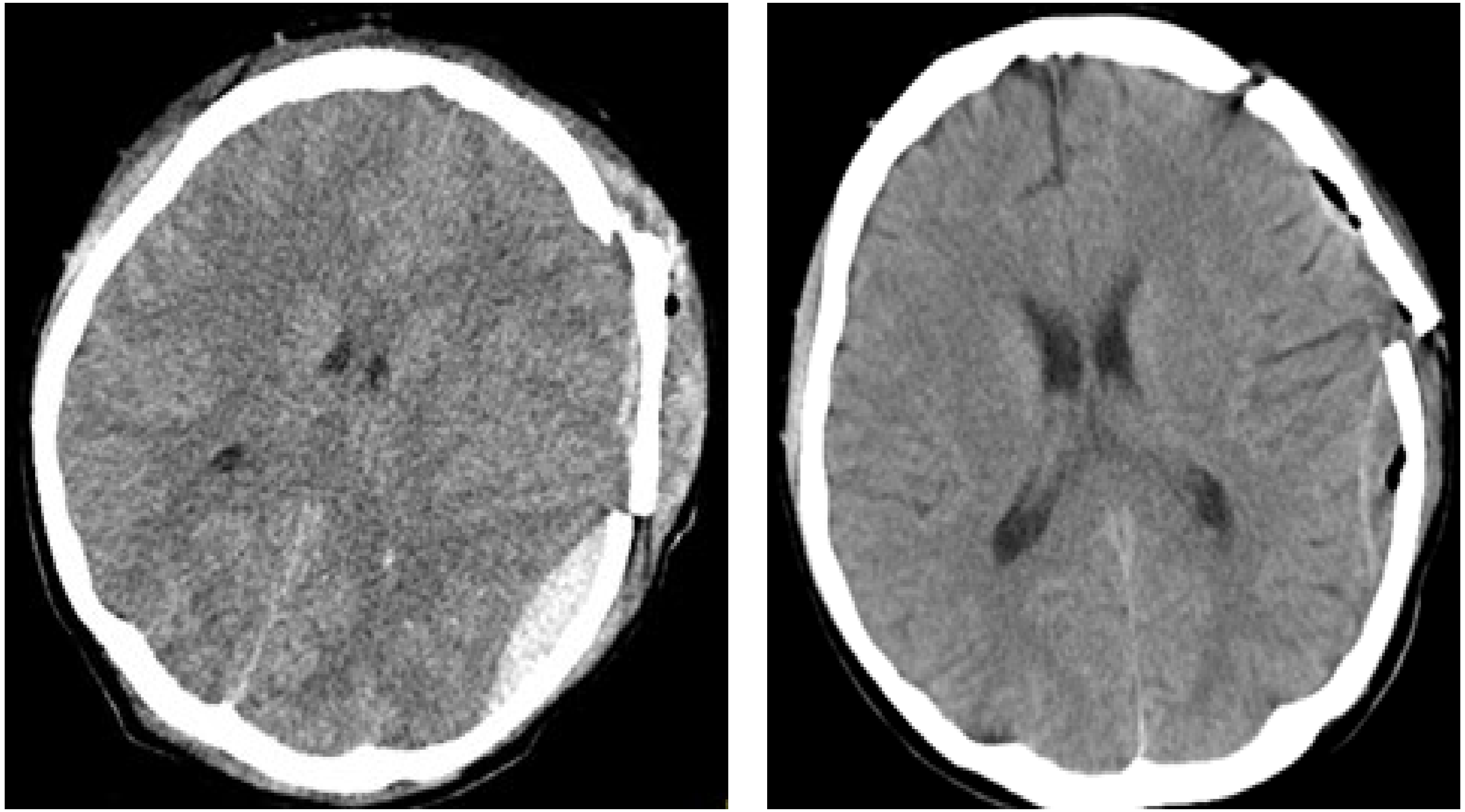
Subacute subdural hematoma

Chronic subdural hematoma

Skull and brain trauma

Chronic epidural hematoma

Skull and brain trauma



CT, same patient: frontal fracture + left parietal epidural hematoma – acute (left) and chronic (right)

Inflammatory and infectious brain disorders

Brain abscess

Cerebral abscess is an accumulation of pus, well delimited by a thick wall that develops inside the cerebral parenchyma. In order to establish the imaging diagnosis of cerebral abscess, CT or MRI examinations can be used.

The CT scan reveals a hypodense lesion well delimited by a thick, iodophilic wall, at the periphery of which there is spontaneous hypodense edema in the adjacent cerebral parenchyma. The presence of intralesional air content is a pathognomonic change for brain abscess. The evolution towards healing is indicated by the decrease in size of the abscess wall, as well as by the decreased parietal iodophilia.

The MRI examination reveals a lesion in hypo T1, hyper T2, well delimited by a thick wall in hypo T2 that presents intense gadophilia. Adjacent edema appears in hyper T2 in the periphery of the abscess. The presence of intralesional air content is a pathognomonic change for brain abscess. The evolution towards healing is indicated by the decrease in size of the abscess wall, as well as by the decreased parietal gadophilia.

Inflammatory and infectious brain disorders

Brain abscess

Demyelinating disorders

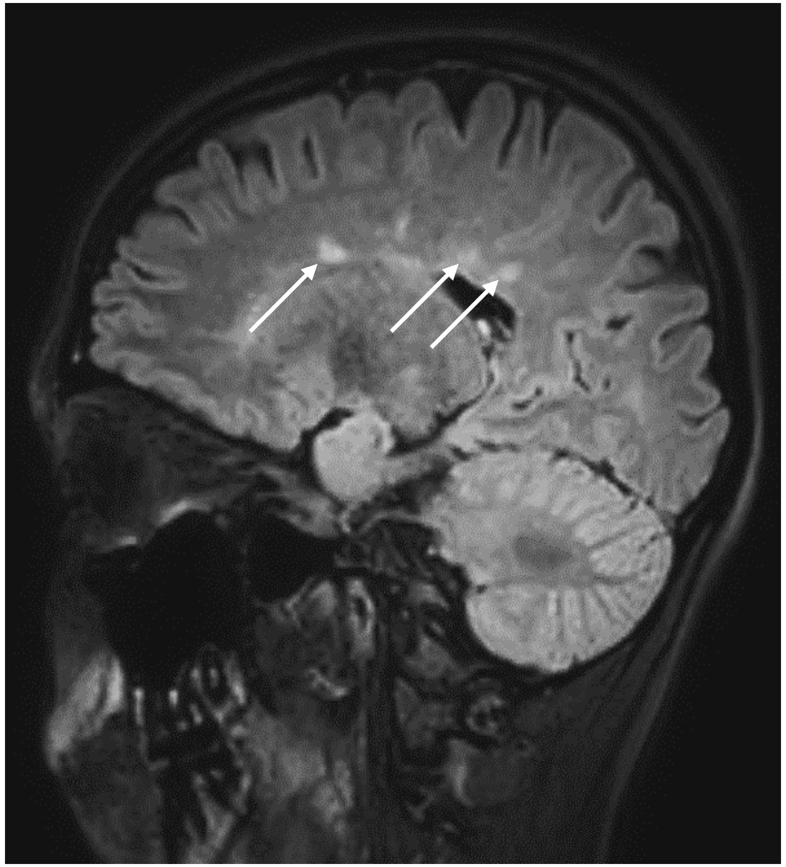
Multiple sclerosis

Multiple sclerosis is the most common demyelinating disease and mainly affects women (W:M 1.5-3:1) around the age of 30-35 years. Descendants of people diagnosed with multiple sclerosis have a risk of up to 10-20 times greater than the general population to develop multiple sclerosis.

The imaging method of choice in patients with multiple sclerosis is MRI. Demyelinating lesions are frequently located at the juxtacortical, periventricular, infratentorial and spinal cord levels. The MRI examination reveals demyelinating lesions as hyper T2 and FLAIR lesions with a tendency to conglomerate around the ventricular system. Also, demyelinating lesions may be oriented perpendicular to the lateral ventricles (Dawson's fingers aspect).

The behavior of the lesions after intravenous administration of the paramagnetic contrast agent highlights the activity level of these lesions. If demyelinating lesions do not enhance the contrast substance, then they are inactive, but if they enhance, then the lesions are active.

Demyelinating disorders



Brain tumors

Gliomas are the most common central nervous system tumors developed from glial cells. Glial cells (also called neuroglia or neuroglial cells) have some important roles:

- neuron support;
- neuron nutrition;
- transmission of the nervous influx;
- digestion of the neuronal remnants.

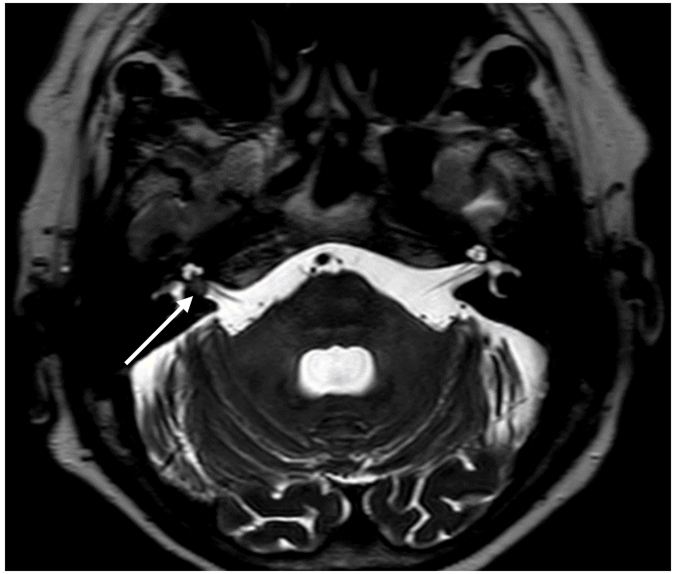
According to the numerical ratio, the glial cells are 10 times more than the neurons and, unlike them, have the ability to divide.

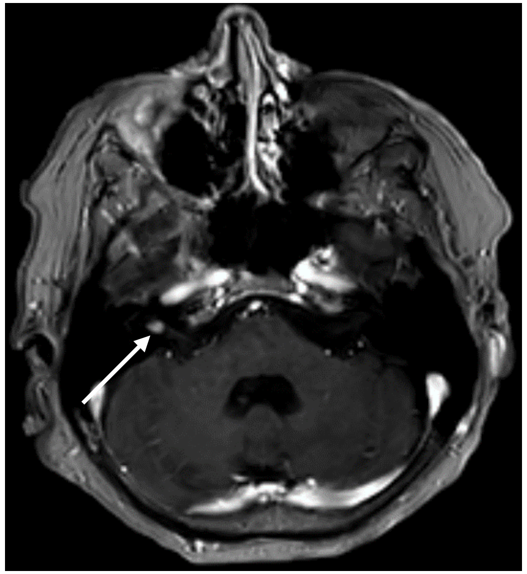
Brain tumors

Acoustic neurinoma

The acoustic neurinoma is an extranevraxial tumor developed along the acoustic-vestibular nerve pathway (VIII). MRI is typically used to establish the imaging diagnosis.

The MRI aspect of the acoustic neurinoma is in iso- / hypo T1, hyper T2, with cystic areas inside and intense contrast enhancement.

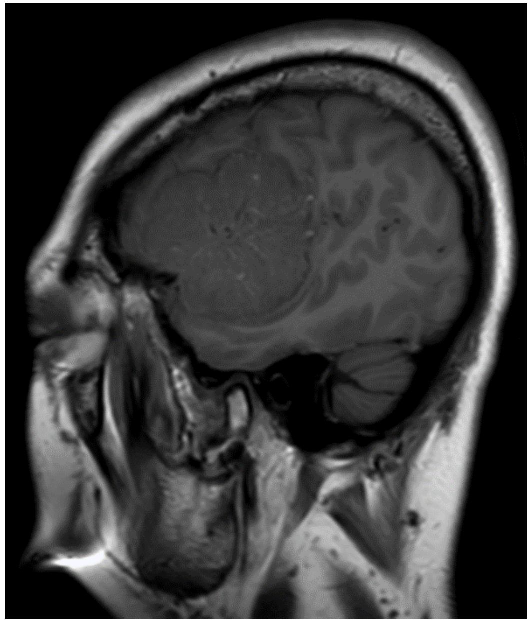
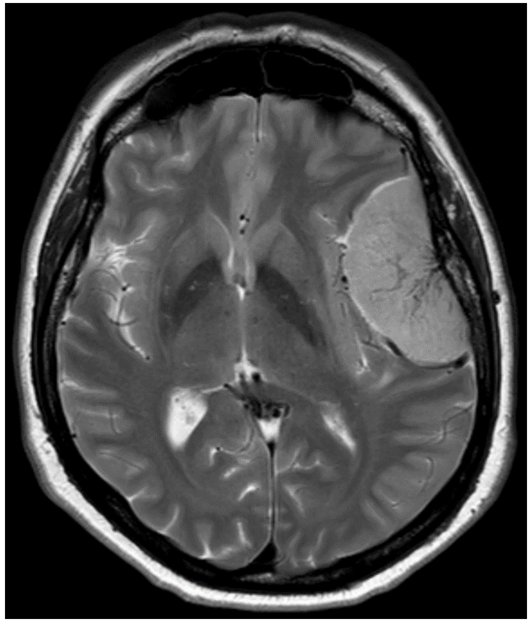
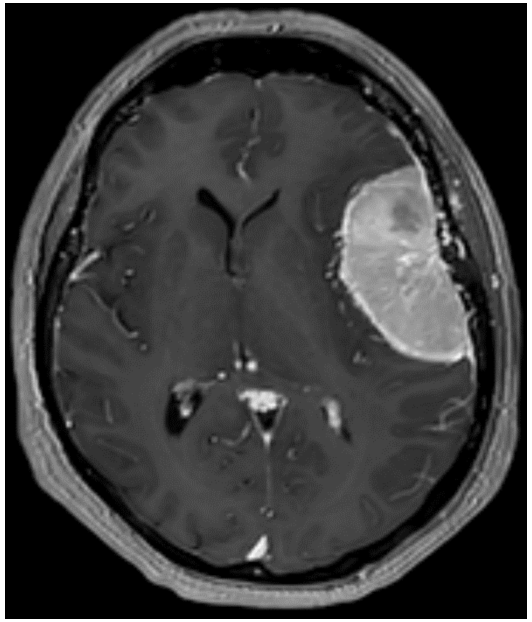




Brain tumors

Meningioma

Meningioma is the most common extranevraxial tumor developed in the meningeal layer. The CT examination reveals a hyperdense mass, relatively homogeneous, well delimited, with small or diffuse calcifications and relatively homogeneous intense contrast enhacenement. The MRI examination reveals a well-delimited round-oval lesion, in iso T1, T2, with intense, relatively homogeneous contrast enhancement.

Brain tumors

Glioblastoma

Glioblastoma is the most frequent intranevraxial malignancy developed in adults. This tumor is extremely aggressive, has resistance to therapy and is associated with an unfavorable prognosis.

The CT examination reveals an irregularly shaped tumor mass, with necrosis inside, surrounded by marked digitiform edema that determines mass effect on the adjacent cerebral parenchyma and / or the ventricular system. Intralesional bleeding is common. Intratumoral calcifications are rare. After contrast administration, the tumor presents intense, heterogeneous and irregular uptake of the contrast agent.

The MRI examination reveals a tumor mass in iso- / hypo T1, hyper T2, with heterogeneous structure and contrast enhancement, with areas of necrosis inside and perilesional digitiform edema.

Brain tumors

Glioblastoma

Brain tumors

Brain metastases

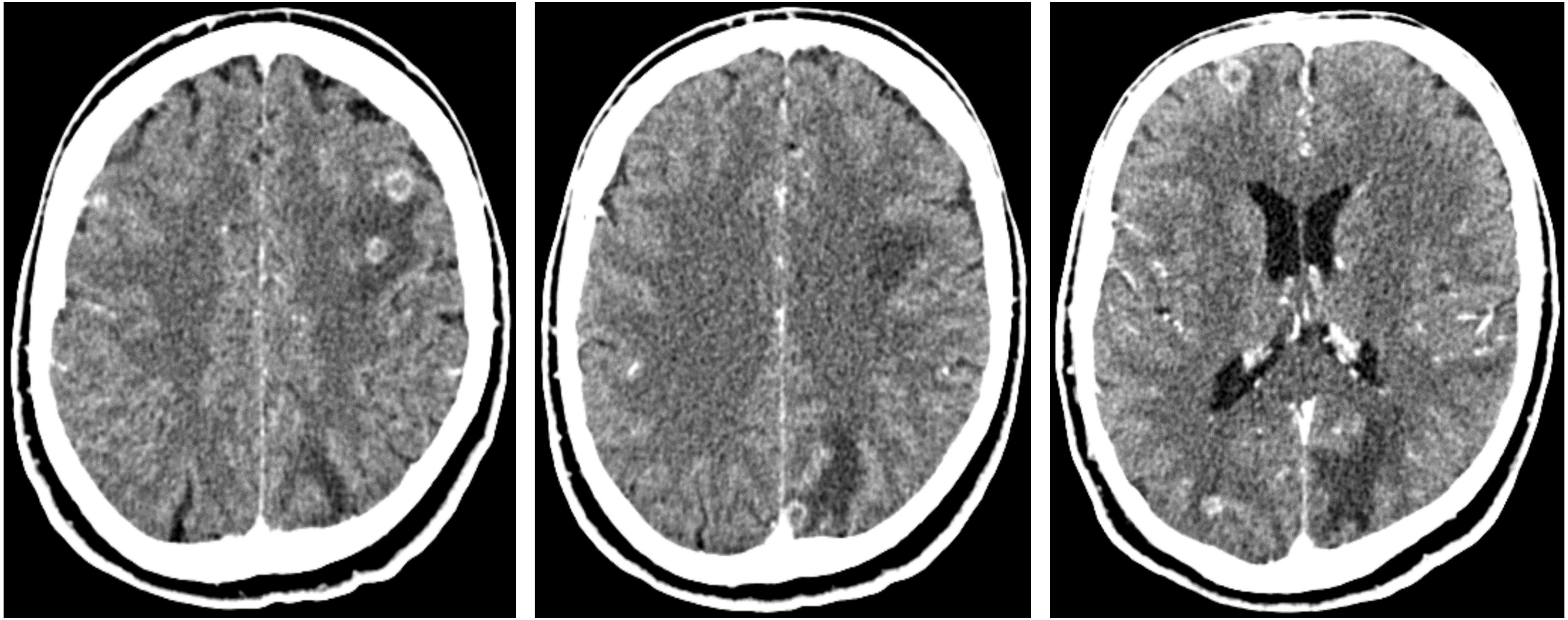
Primary tumors that most commonly cause secondary brain lesions include bronchopulmonary cancer, breast cancer and malignant melanoma.

The CT scan often reveals multiple iso- / hypodense lesions, with peripheral ring enhancement and perilesional digitiform edema. Intralesional hemorrhage offers a hyperdense appearance.

The MRI examination often reveals multiple lesions that enhance the contrast agent mostly in the periphery and are accompanied by perilesional digitiform edema. The intralesional hemorrhagic content generates hypersignal in the T1 sequence.

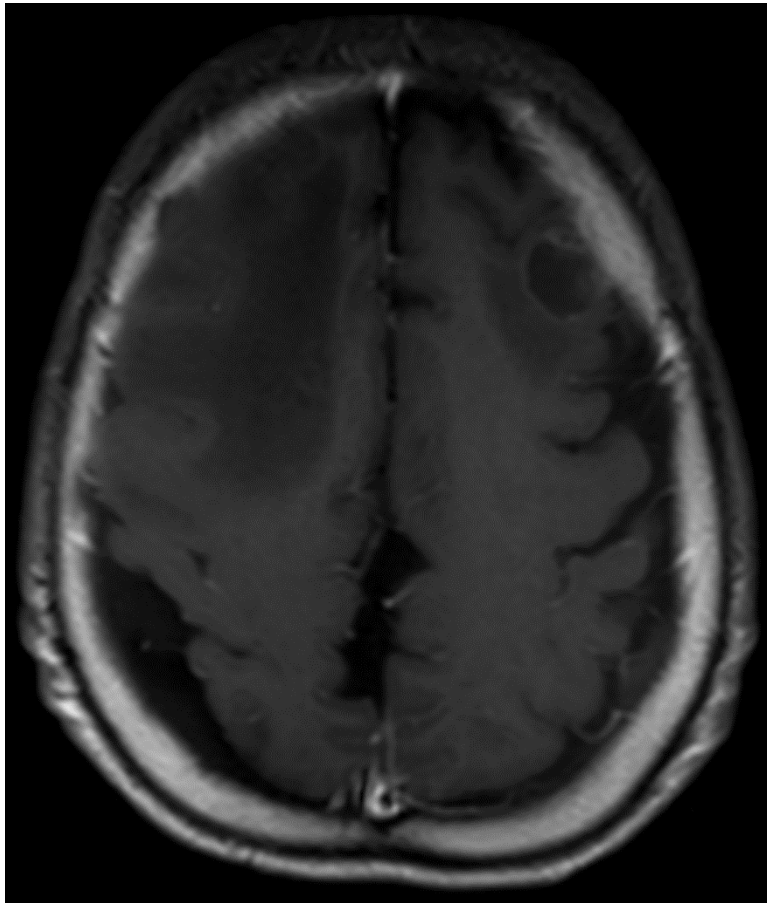
Brain tumors

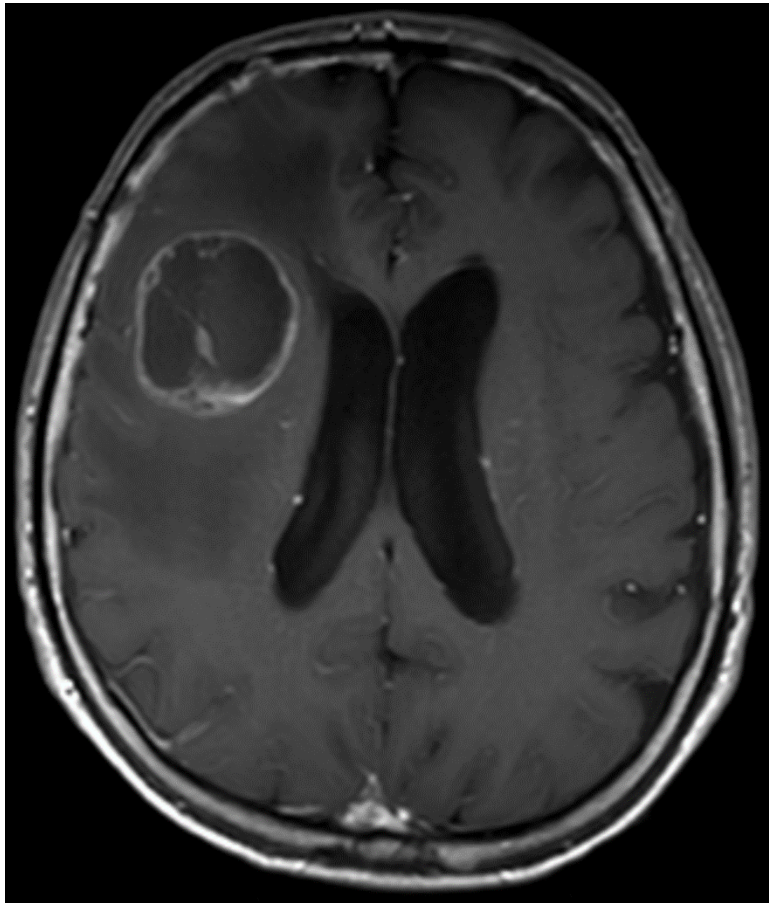
Brain metastases

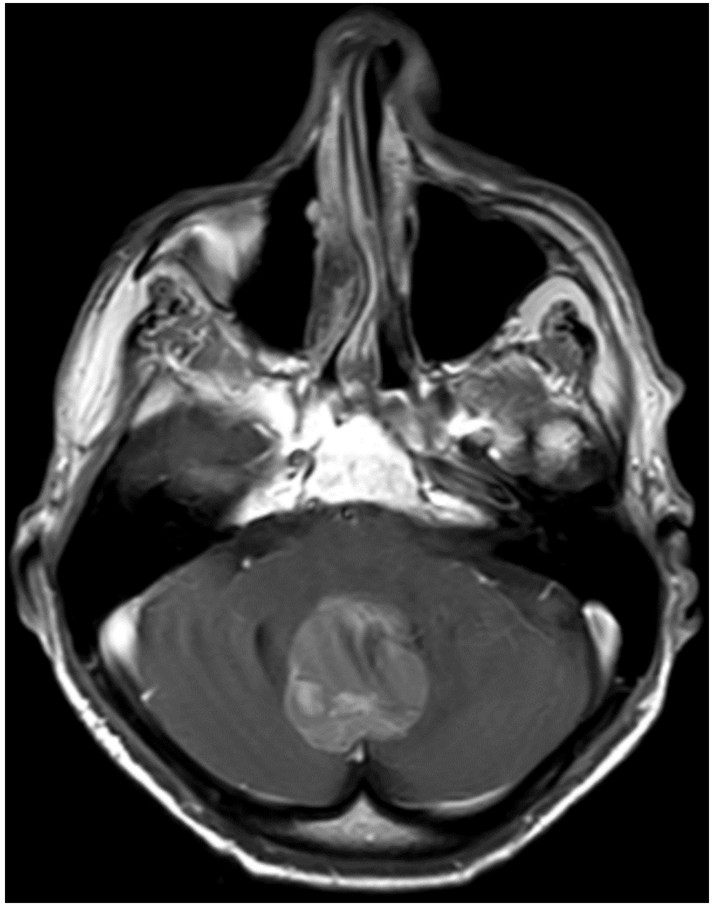


Brain tumors

Brain metastases





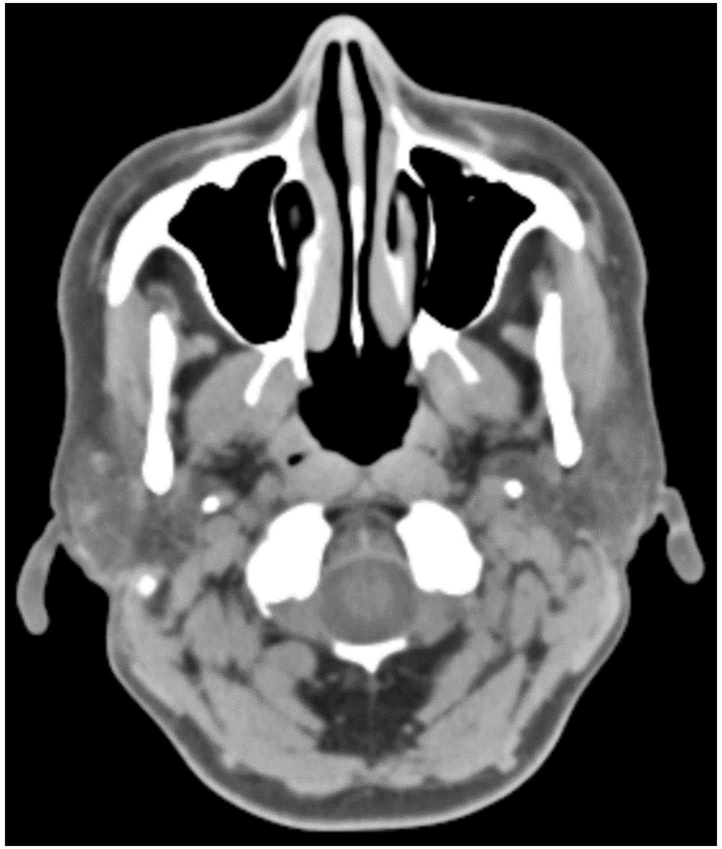


Introductive data about thyroid imaging

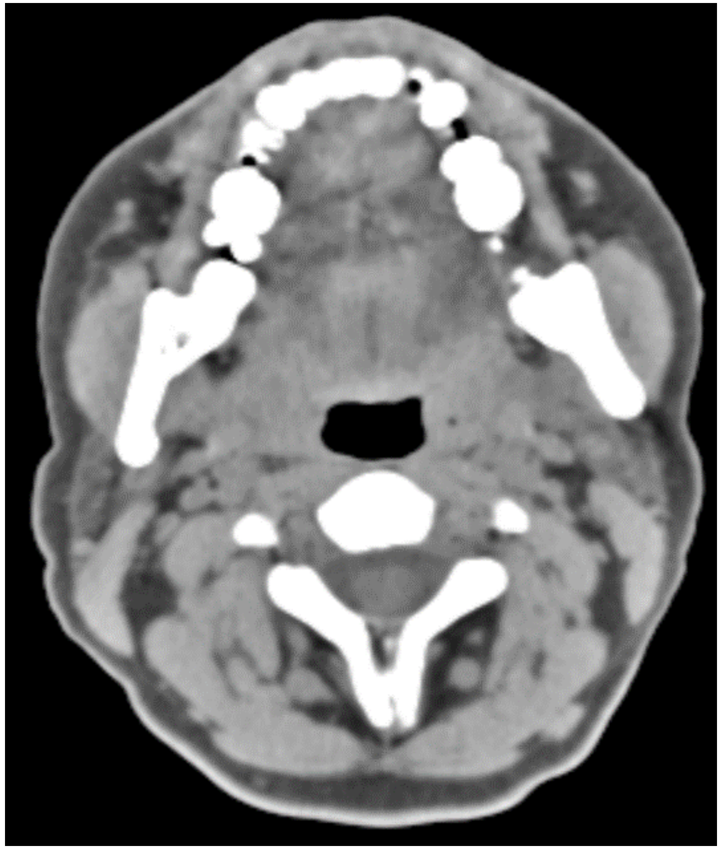
The detection of thyroid nodules is performed using ultrasonography and can then be followed by fine needle aspiration biopsy (FNAB) in order to evaluate the cytology and exclude malignancy. Sometimes, scintigraphic exploration of the thyroid nodules is required before FNAB is performed. Thyroid scintigraphy can differentiate between functional/"hot" nodules (very rarely malignant) and nonfunctional/"cold" nodules (7-10% malignant).

CT and MRI scans are recommended in the evaluation of multinodular goiter, as well as in the case of thyroid carcinomas in order to evaluate the local tumor extension, the presence of suspicious local lypmhadenopathies and secondary lesions.

Introductive data about neck imaging

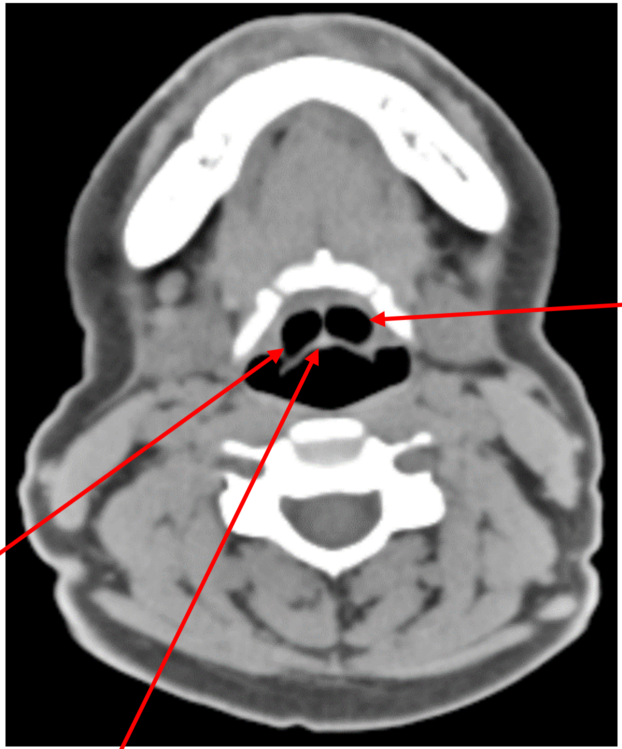


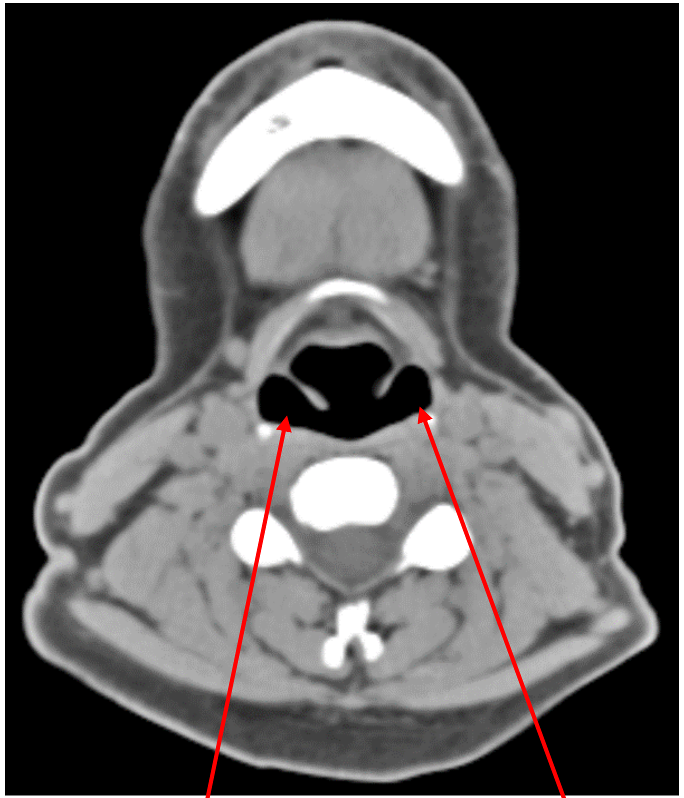
Nasopharynx, CT, normal aspect



Oropharynx, CT, normal aspect

Introductive data about neck imaging

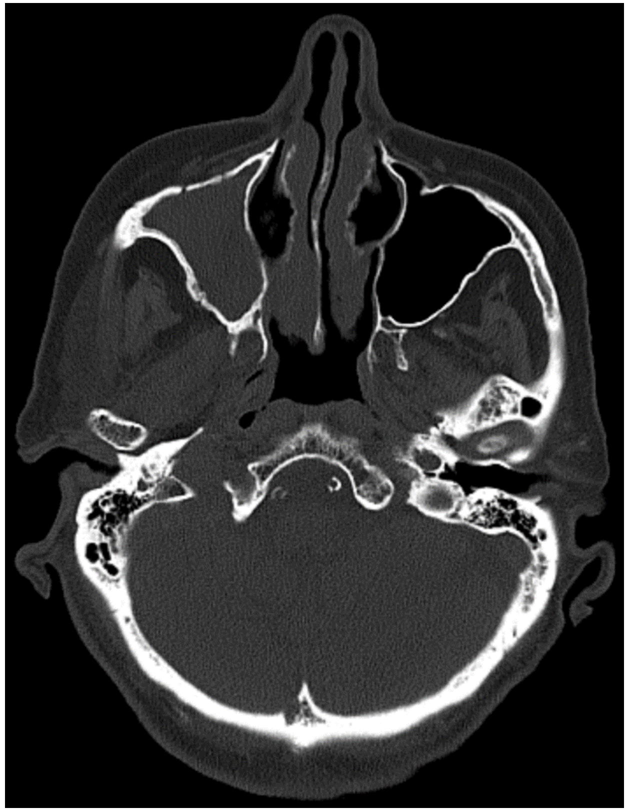


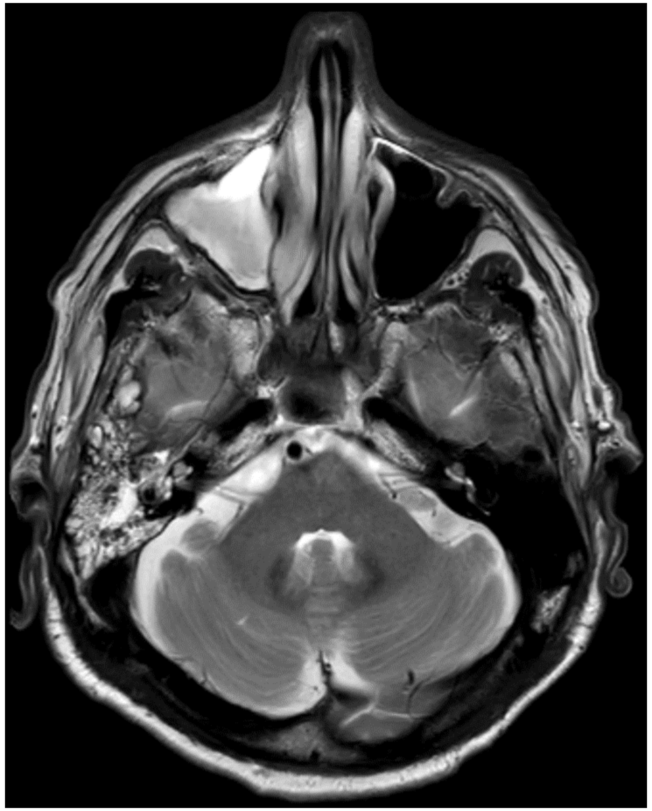


Introductive data about rhinopharynx and paranasal sinuses

Paranasal sinuses are air spaces located around the nasal cavity and communicate with it. They are represented by: the frontal sinuses, the ethmoid cells, the sphenoidal sinuses and the maxillary sinuses.

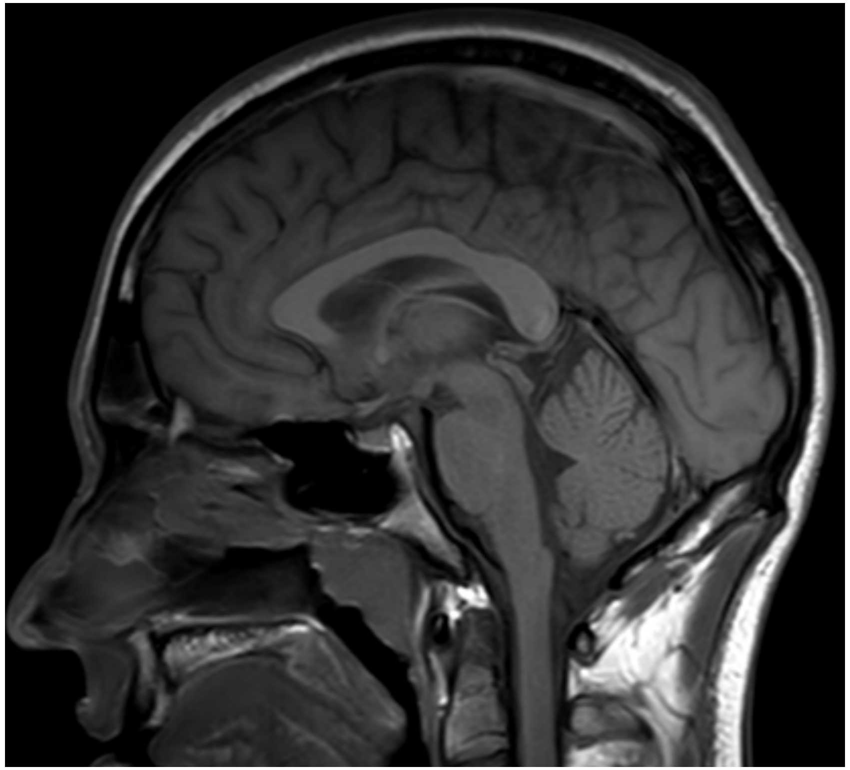
The imaging exploration of the paranasal sinuses can be performed using conventional radiography, CT and MRI. In case of an inflammatory process that affects the paranasal sinuses, the conventional x-ray will reveal an opacified sinus cavity, while the CT and MRI examinations will show a thickening of the mucosa and fluid inside the affected sinuses.

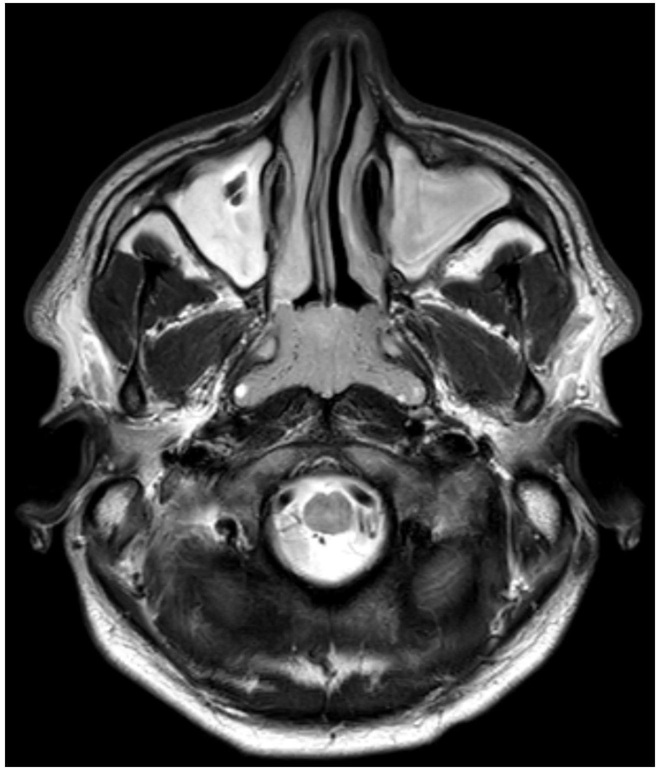




Introductive data about rhinopharynx and paranasal sinuses

Adenoid hypertrophy represents an enlargement of the adenoid vegetations and may cause partial or complete obstruction of the rhinopharynx. For diagnosis, a CT or MRI exam is recommended.





Introductive data about rhinopharynx and paranasal sinuses

The Thornwaldt cyst is a well delimited round-oval lesion, with fluid content inside, developed on the midline of the posterior wall of the rhinopharynx. For diagnosis, CT or MRI scans are recommended. On the CT examination, the Thornwaldt cyst appears as a well-delimited round-oval lesion, with fluid densities, homogeneous, no contrast enhancement, located on the posterior wall of the rhinopharynx, on the midline. On the MRI examination, this lesion is seen as a well-delimited round-oval area, with signal similar to fluid inside (hyposignal T1, hypersignal T2), no contrast enhancement, no restricted diffusion, located on the midline, on the posterior wall of the rhinopharynx.

Introductive data about rhinopharynx and paranasal sinuses

Tumors developed in the rhinopharynx can be properly assessed through CT and MRI. The CT examination reveals an asymmetry of the rhinopharynx caused by a mass that enhances intensely after contrast administration and is located on the upper floor of the pharynx. Furthermore, the CT scan evaluates the relationship of the tumor with the neighbouring anatomical structures (osteolysis, tumoral extension in the lateral pharyngeal recess etc.) and detects suspicious laterocervical and jugulo-carotid lymphadenopathies and metastases. On the other hand, MRI scans reveal nasopharyngeal masses as areas in iso-/hypo T1, iso-/hyper T2 with heterogeneous contrast enhancement.

Introductive data about oropharynx and parotid glands

The oropharynx is the middle part of the pharynx and communicates superiorly with the nasopharynx and inferiorly with the hypopharynx. For the evaluation of this region, the most used imaging methods are CT and MRI.

Oropharyngeal tumors develop frequently on the tongue base, on the mobile part of the tongue, on the hard palate, on the soft palate, on the palatine tonsils or on the buccal floor and are characterized by an increased rate of metastasis in the loco-regional lymphadenopathies.

On the CT examination, we observe an asymmetry of the oropharyngeal region, and the tumors appear iso- / hypodense, with heterogeneous structure and iodophilia, with necrotic areas inside that can extend in the adjacent anatomical structures depending on the location. In addition, the CT examination detects suspicious latero-cervical and jugulo-carotid lymphadenopathies, as well as distant metastases.

The MRI examination reveals the oropharynx tumor as iso- / hypoT1, iso-/ hyper T2, with heterogeneous structure and gadophilia, with loco-regional extension.

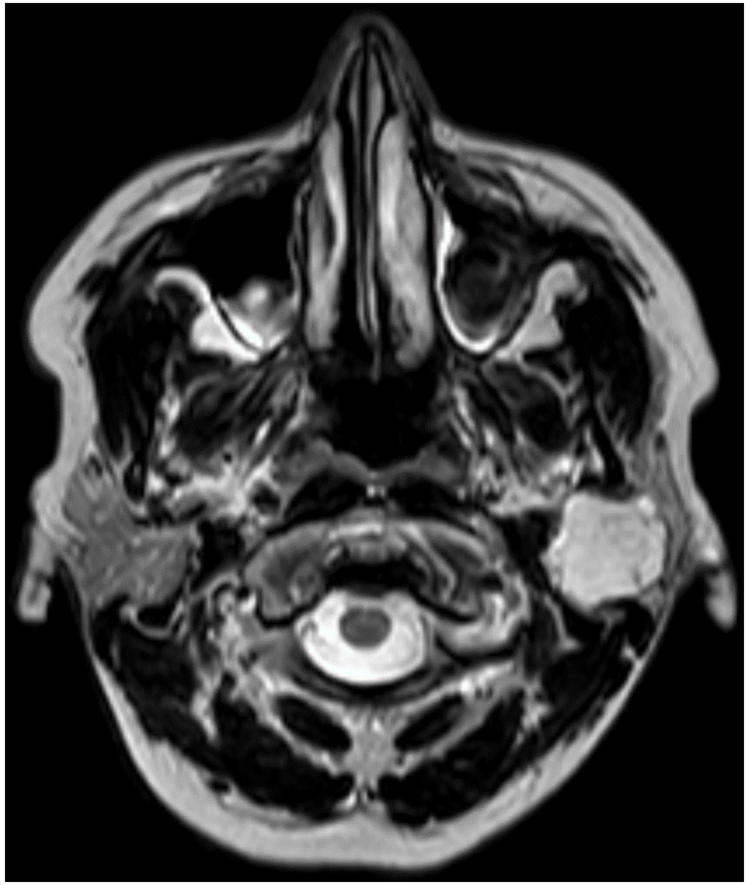
Introductive data about oropharynx and parotid glands

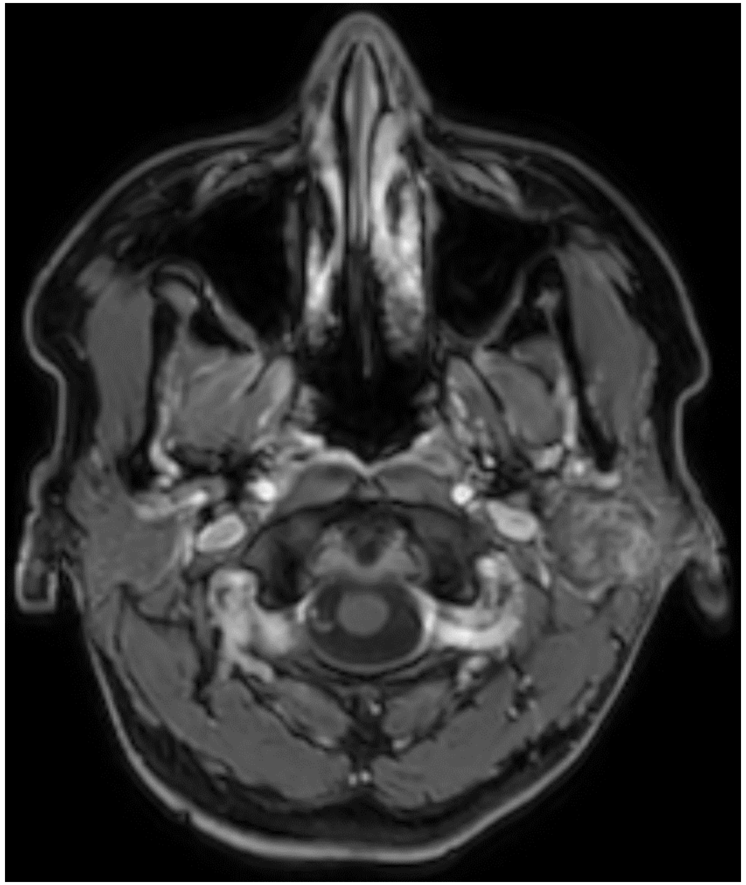

Introductive data about oropharynx and parotid glands

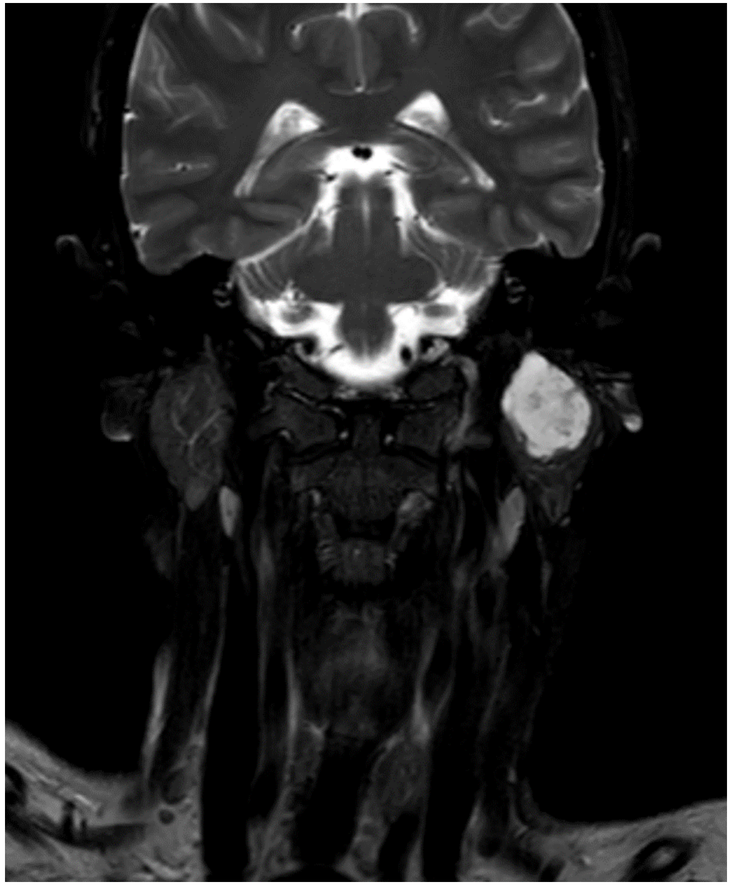
The parotid glands are paired salivary glands that eliminate their contents in the oral cavity through the parotid duct. Due to their superficial disposition in the cephalic region, the parotid glands can be easily examined through ultrasonography. Also, the pathology of the parotid glands can be further assessed through CT and MRI.

The Warthin tumor is one of the most common benign tumors developed in the salivary glands, usually in the parotid glands. For imaging diagnosis, ultrasonography, CT and MRI can be used. On ultrasound, the lesion is well delimited and has mixed content (solid - hypoechoic; fluid - transsonic) and vascular signal is presented on the Doppler examination. The CT examination reveals a single lesion or multiple lesions, well delimited, with mixed content (fluid and tissue), with iodophilia in the intralesional tissue component. On the MRI examination, this type of tumor is seen as iso-/ hypo T1, iso-/ hyper T2, with gadophilia in the tissue component inside the lesion.

Introductive data about oropharynx and parotid glands







Introductive data about hypopharynx and larynx

Normally, the CT and MRI scans reveal a symmetry of the hypopharyngeal and laryngeal structures and no pathological contrast enhancements in these regions. In case of tumors developed in the hypopharynx or larynx, the two examinations, CT and MRI, initially reveal an asymmetry in the affected area due to a mass with heterogeneous structure and contrast enhancement. The two imaging techniques aforementioned allow a complete characterization of the local tumor, specifying the tumor size and extension in the adjacent structures, if there are any suspicious regional lymphadenopathies or distant metastases.