

# Clinics in diagnostic imaging (96)

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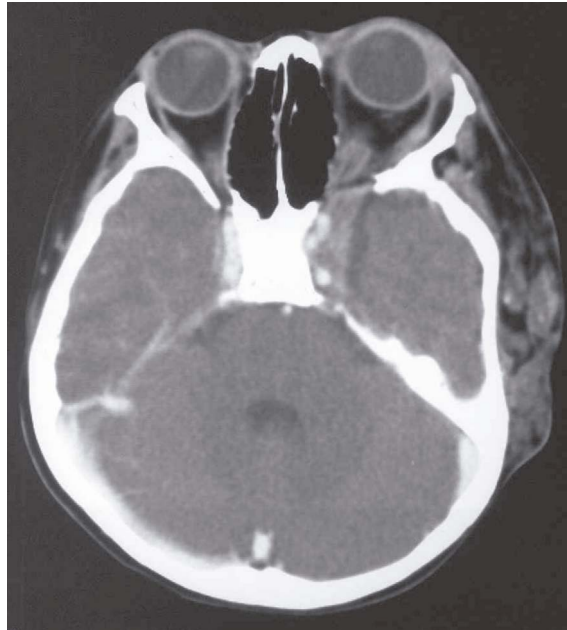


Fig. 1a Enhanced axial CT image taken through the level of the orbits.

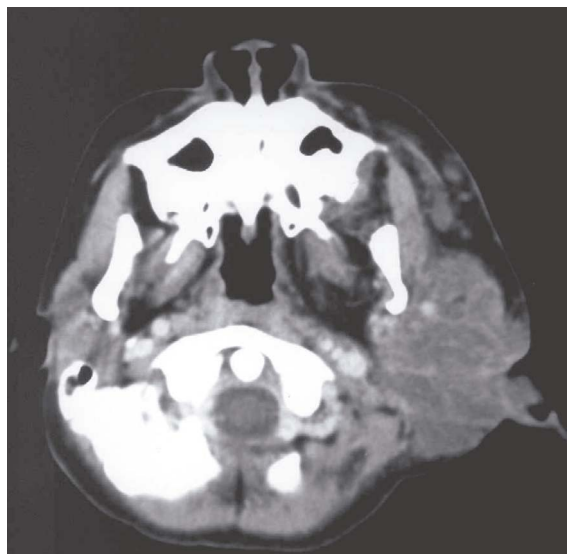


Fig. 1b Enhanced axial CT image taken through the level of the parotid glands.

## CASE PRESENTATION

A 10-year-old boy had a mass on the left side of his face for many years. The mass was increasing in size. He was deaf in his left ear and had limited vision of

the left eye, being able to see only a short distance. What does computed tomography (CT) (Figs. 1a & b) of his face and neck show? What is the diagnosis?

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**Fig. 2** Bilateral acoustic neuromas. Enhanced axial T1-W MR image shows an enhancing mass in each acoustic canal (arrows).

#### IMAGE INTERPRETATION

Enhanced axial CT of the neck (Fig. 1b) shows a multilobulated low-attenuation mass in the left parotid space. There is nodularity and involvement of branches of the facial nerve, creating a “bag of worms” appearance. The left pterygoid muscles are small because of denervation atrophy. There is a mass in the left orbital apex that extends into the left cavernous sinus, exophthalmos of the left eye, and erosion of the medial portion of the greater wing of the left sphenoid (Fig. 1a).

#### DIAGNOSIS

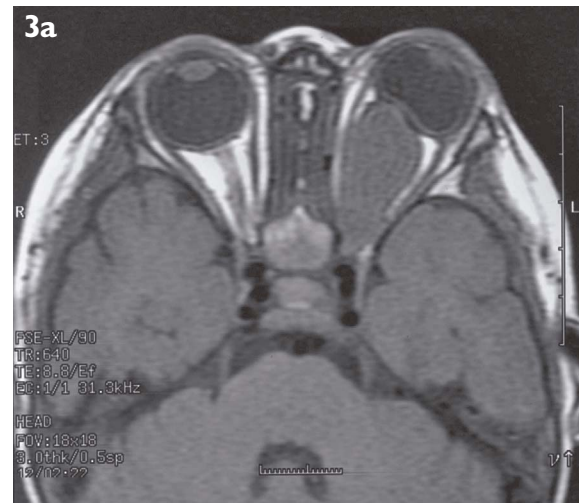
Plexiform neurofibromatosis.

#### CLINICAL COURSE

The mass in the left parotid space was partially removed. Histopathological examination revealed plexiform neurofibromas. With the combination of plexiform neurofibromas and sphenoid dysplasia, the patient was diagnosed to have neurofibromatosis type 1 (NF1). He was seen two more times in the two years after surgery. The size of the residual mass remained unchanged during this follow-up period.

#### DISCUSSION

Tumours of neurogenic origin are a small but significant portion of head and neck masses in children. Neurofibromas and schwannomas are the most common nerve sheath tumours of the peripheral nerves in the head and neck<sup>(1)</sup>. There are three types of neurofibromas, namely: localised, diffuse, and plexiform. The vast majority of these lesions are



**Fig. 3** Left optic nerve glioma. Unenhanced (a) axial spin-echo (SE) T1-W and (b) fat-suppressed fast SE (FSE) T2-W MR images show massive enlargement of the left optic nerve. (c) Enhanced coronal fat-suppressed SE T1-W MR image shows diffuse enhancement of the enlarged left optic nerve (arrow).

localised and have no association with NF1, although any of these lesions may occur in NF1<sup>(2)</sup>.

Plexiform neurofibromas are pathognomonic of NF1. These lesions usually occur in early childhood and precede cutaneous neurofibromas. Plexiform

neurofibromas involve a long nerve segment and its branches in a diffuse and tortuous expanding manner. Grossly, it has been described as a “bag of worms”<sup>(2)</sup>. Generally, an unencapsulated tumour that blends with adjacent connective tissue or peripheral nerves is seen<sup>(3)</sup>. Rapid enlargement of an existing neurofibroma should be considered a sign of malignant transformation, until proved otherwise. There is a 4% chance of transformation into a malignant peripheral nerve sheath tumour in NF1<sup>(3)</sup>.

In the head and neck region, plexiform neurofibromas tend to progress along the nerve of origin into the intracranial spaces, causing distortion and compression of the brain. Plexiform neurofibromas appear as masses that usually arise in the region of the orbital apex or superior orbital fissure in the distribution of the first division of the trigeminal nerve. They impair ocular movement and produce exophthalmos. Careful evaluation of images often reveals extension of orbital tumours into the cavernous sinus, nasopharynx, or pterygomaxillary fissure<sup>(4)</sup>.

Plexiform neurofibromas are seen on CT as large multilobulated masses<sup>(5)</sup>. There is often nodularity and involvement of nerve branches, creating a “bag of worms” appearance<sup>(2)</sup>. On unenhanced CT, plexiform neurofibromas typically have a low attenuation, similar to other neurofibromas. This may be related to the fat content of myelin from Schwann cells, the high water content of myxoid tissue, entrapment of fat, and cystic areas of haemorrhage and necrosis<sup>(2,3)</sup>.

MR imaging of plexiform neurofibromas shows a large conglomerate mass consisting of numerous neurofibromas and diffuse thickening of the involved nerve, often extending into nerve branches<sup>(5)</sup>. The signal intensity of plexiform neurofibromas is similar to that of other neurofibromas and that of muscle on T1-weighted images<sup>(2)</sup>. On T2-weighted images, the lesions are sometimes homogeneously hyperintense or may have a characteristic target sign<sup>(5)</sup>. This sign consists of low-to-intermediate signal intensity centrally, with a ring of high signal intensity peripherally. This finding comes from fibrous tissue with high collagen content located centrally, and more myxoid tissue located peripherally<sup>(2)</sup>.

On MR imaging, neurofibromas and malignant peripheral nerve sheath tumours may be indistinguishable. The different signal intensity characteristics of lesions with a higher degree of anaplasia are useful. Other factors, such as a more rapid and infiltrative growth pattern, suggest malignant peripheral nerve sheath tumors, while finding of the target sign on T2-weighted MR images suggests neurofibromas<sup>(3,6)</sup>.

Contrast enhancement on CT or MR imaging is variable in both neurofibromas and malignant peripheral nerve sheath tumours. In general, a greater degree of contrast enhancement is apparent in malignant peripheral nerve sheath tumours. The pattern of

enhancement varies but is usually either diffusely-heterogeneous or peripheral. Lesions demonstrating the target sign typically enhance more prominently centrally. Irregular nodular peripheral enhancement with central necrosis is typical of malignant peripheral nerve sheath tumours<sup>(2)</sup>.

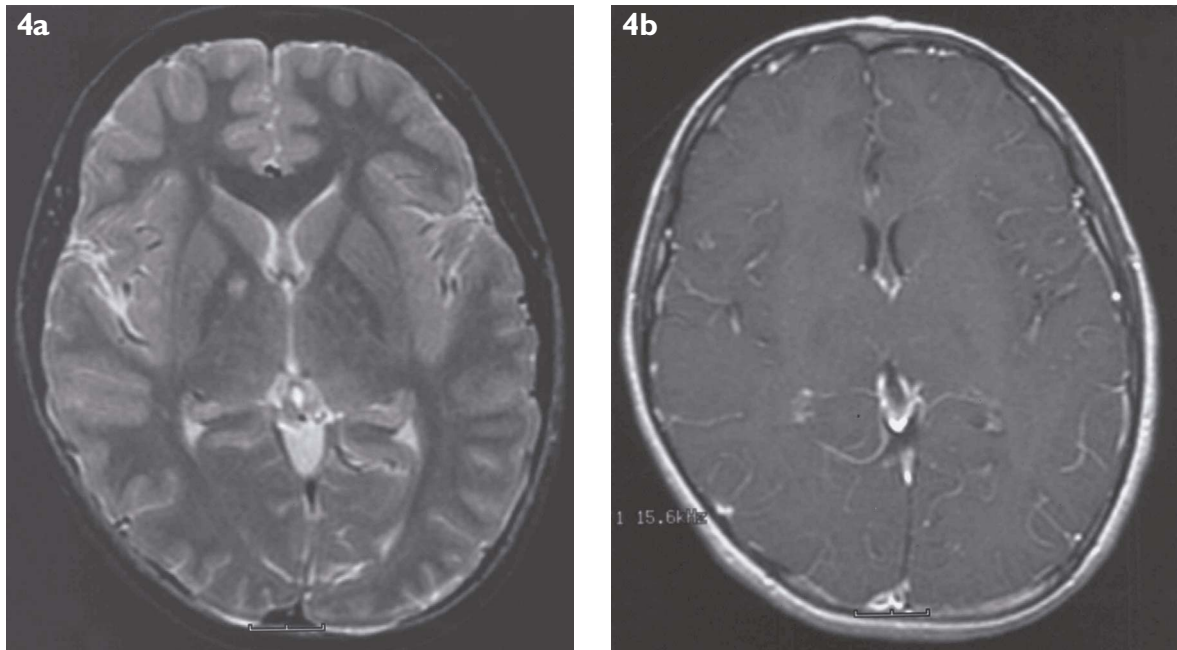
Neurofibromatosis is a phakomatosis with neurocutaneous abnormalities and involvement of multiple organ systems. There are two major forms, designated NF1 and neurofibromatosis type 2 (NF2), both of which are clinically and genetically distinct<sup>(5)</sup>. NF1 is characterised by multiple neurofibromas along the peripheral nerves, optic nerve gliomas, sphenoid wing dysplasia, pigmented iris nodules, and hyperpigmented macular skin lesions known as café-au-lait spots<sup>(3)</sup>. NF2 affects primarily the central nervous system, with occurrence of bilateral acoustic neuromas (Fig. 2), gliomas, or meningiomas<sup>(2,5)</sup>.

NF1 is among the most common genetically-transmitted diseases, being found in one in 3000 births. It is autosomal dominantly inherited, although up to 50% of cases may arise from a new mutation<sup>(5)</sup>. The genetic abnormality of NF1 patients has been localised to the neurofibromin gene located on the long arm of chromosome 17. This gene is a tumour suppressor gene, the malfunction of which results in part in benign and occasionally malignant sensory nerve tumours<sup>(7)</sup>. Plexiform neurofibroma is one of the craniofacial abnormalities found in patients with NF1. Other cranial abnormalities in these patients are discussed in greater detail in the paragraphs following.

#### **Optic pathway gliomas**

The most common primary brain abnormality in NF1 is optic pathway glioma. Its incidence may be as high as 15%. However, only about one-half of affected patients will develop signs or symptoms of their tumours<sup>(4)</sup>. The tumors can arise anywhere along the optic pathway, from just behind the globe to the occipital cortex<sup>(7)</sup>. In children, although optic pathway gliomas are almost always low-grade astrocytomas, some can be highly malignant, requiring very aggressive treatment<sup>(4)</sup>. Tumours that are restricted to the optic nerves may be asymptomatic or be accompanied by visual loss. Patients with tumours that involve the optic chiasm and hypothalamus may have precocious puberty<sup>(4)</sup>.

Optic pathway gliomas can occur in children without NF1. Kornreich et al found that there were several morphological features that distinguish optic pathway gliomas in children with NF1 from optic pathway gliomas in children without NF1. In children with NF1, the tumour was smaller, the original shape of the optic pathway was preserved, and cystic components were uncommon (Fig. 3). On imaging, the tumour



**Fig. 4** Unidentified bright objects. (a) Axial FSE T2-W MR image of a 12-year-old girl with neurofibromatosis type I shows a few foci of increased signal intensity in both globi pallidus. (b) Enhanced axial SE T1-W MR image shows no enhancement of the lesions.

appeared as a thickening of the optic nerve and/or chiasm. In children without NF1, the chiasm and hypothalamus were the most commonly- affected sites, the tumour was larger, and cystic components were frequently seen, as was extension beyond the optic pathways<sup>(7)</sup>.

#### **Other gliomas**

Astrocytomas are more common in patients with NF1 than in the general population. They are most commonly juvenile pilocytic astrocytomas, but other low-grade and higher grade tumours also occur<sup>(4)</sup>. In patients with NF1, astrocytomas most commonly occur in the optic nerve/chiasm but are sometimes found elsewhere in the brain. The brainstem, cerebellum, and the cerebral hemisphere are common locations for astrocytomas in children with NF1<sup>(4)</sup>.

#### **Unidentified bright objects**

On cranial MR images in children with NF1, high signal intensities are seen on T2-weighted images<sup>(9)</sup>. These are seen in the pons, cerebellar white matter, the internal capsule, and the splenium of the corpus callosum. The corresponding lesions are characteristically multiple. They have no mass effect, do not cause vasogenic edema, have normal signal on T1-weighted images, and do not enhance. They are seen in about 75% of children with NF1, and more than 90% of NF1 children with optic gliomas<sup>(4)</sup>. DiPaolo et al have shown that these represent regions of myelin vacuolisation and areas of separation of the layers of myelin as they spiral around the axon<sup>(10)</sup>.

These lesions are typically absent in the first two years of life, then begin to appear at about three years of age. They increase in number and size until the age of 10 to 12 years, after which they decrease in number and size. They are almost never seen in patients over the age of 20 years<sup>(4)</sup>.

Foci of abnormal signal intensity are also seen in the globus pallidus of patients with NF1 (Fig. 4). The foci also represent areas of myelin vacuolisation. These regions have a somewhat different radiological appearance from those in the cerebellum as they are sometimes slightly hyperintense on T1-weighted images, in addition to being hyperintense on T2-weighted images. The characteristic lack of enhancement, location, bilaterality, and slight hyperintensity on T1-weighted images help to differentiate these lesions from astrocytomas<sup>(4)</sup>.

#### **Bone dysplasia**

Other intracranial manifestations of NF1 include sphenoid wing dysplasia and dysplasia of bone along the lambdoid suture. Only sphenoid dysplasia is of any clinical importance because it may result in herniation of the temporal lobe into the orbit. The pulsation of the temporal lobe may be transmitted through the globe, thus being visible externally as pulsatile exophthalmos or enophthalmos secondary to atrophy of orbital contents. The globe may be dysplastic or hypoplastic. Sphenoid wing dysplasia is often associated with plexiform neurofibromas in the orbit or periorbital regions<sup>(4)</sup>. Jacquemin et al reported that patients with craniofacial neurofibromatosis

frequently had bony orbital deformity, always with an optic nerve glioma or orbital plexiform neurofibromas. Plexiform neurofibromas were associated with four types of orbital-bone changes, namely: expansion of the middle cranial fossa into the posterior orbit, enlargement of the orbital rim, bone erosion and decalcification by contiguous tumour (as in our patient), and enlargement of the cranial foramina<sup>(11)</sup>.

Other craniofacial abnormalities in patients with NF1 include macrocephaly<sup>(12)</sup>, a larger mid-sagittal surface area of corpus callosum<sup>(13)</sup>, and vascular dysplasia. The latter may consist of stenosis or occlusion of the carotid artery or proximal middle cerebral or anterior cerebral artery, cerebral aneurysm, or arteriovenous fistula<sup>(4)</sup>.

#### ABSTRACT

**A 10-year-old boy presented with a mass on the left side of his face for many years, left ear deafness, and limited vision in the left eye. Enhanced CT of the face and neck showed a multilobulated low-attenuation mass in the left parotid space, with nodularity and involvement of branches of the left facial nerve. There was a mass in the left orbital apex that extended into the left cavernous sinus, exophthalmos of the left eye, and erosion of the medial portion of the greater wing of the left sphenoid. Partial removal of the mass in the left parotid space was performed. Histopathological examination revealed plexiform neurofibromas. CT and MR imaging findings in neurofibromatosis type I patients with craniofacial abnormalities are discussed.**

**Keywords:** plexiform neurofibroma, neurofibromatosis type I, computed tomography, magnetic resonance imaging

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