Neurofibromatosis is one of the most commonly inherited single-gene disorders in humans. Two clinical presentations occur: the first is NF1, or von Recklinghausen disease, which presents with neurofibromas involving peripheral nerves and occurs in 85% of patients with NF; the second is NF2, in which patients are prone to the development of schwannomas, which tend to be central in location.

The NF1 neurofibromas and NF2 schwannomas are collectively classified as NSTs due to their site of origin. These NSTs can present as malignancies as well.

CASE REPORT

This 44-year-old man presented with a history of NF1. His paternal grandmother had NF1, and the disease developed in three of her five sons as well. Two clinical presentations occur: the first is NF1, or von Recklinghausen disease, which presents with neurofibromas involving peripheral nerves and occurs in 85% of patients with NF; the second is NF2, in which patients are prone to the development of schwannomas, which tend to be central in location. The NF1 neurofibromas and NF2 schwannomas are collectively classified as NSTs due to their site of origin. These NSTs can present as malignancies as well. This case report presents a patient with NF1 in whom many of the sequelae of this disease are illustrated, and we also provide an update on the literature published between 2001 and 2005 concerning NF1- and NF2-associated NSTs.
scan and was resected. According to his mother, the histological findings confirmed an astrocytoma of unknown grade. The patient nevertheless received 6 weeks of radiation therapy to the brain. In 2002 he sustained a left-sided ischemic neurological deficit, which was reversible. This event presented as an expressive dysphasia with right-sided weakness.

In April 2005, he complained of severe back pain and leg weakness. An MR image revealed a T11–12 intraspinal hematoma arising from a possible tumor; the hematoma was removed, with negative results on biopsy sampling for tumor. Postoperatively, the patient was able to walk with the aid of crutches.

A severe thoracic kyphoscoliosis (Fig. 3) developed in this patient and was accompanied by excruciating pain in August 2005. By September 2005, the patient manifested a significant right-sided thoracolumbar “hump” with thoracic rib elevation, and his torso was flexed forward at a 90° angle, making him unable to sit in a wheelchair. He had no bowel or bladder difficulties, but had a thoracic myelopathy and left leg plegia, as well as a right leg paresis on examination. On plain x-ray films, a 110° curve at T-10 and T-11 was found, with the apex of the deformity centered at T-10. The patient underwent an anterior and posterior approach for correction of his kyphoscoliosis and fusion in October 2005.

**NEUROFIBROMATOSIS TYPE 1**

*Incidence and Genetics*

Neurofibromatosis Type 1 is seen in approximately one in 2500 births, although an incidence of one in 3000 to 4000 births has recently been reported by some authors. Fifty percent of cases of NF1 arise sporadically as new mutations. Alternatively, NF1 can be transmitted in an autosomal-dominant fashion with almost 100% penetrance and variable expressivity, resulting in variations in the familial clinical manifestations. The disease is caused by a defect on the long arm of chromosome 17, specifically. This region encodes for the protein neurofibromin, and thus is a tumor suppressor gene. Neurofibromin reduces cell proliferation by accelerating the inactivation of the protooncogene p21-ras, which plays a central role in intracellular mitogenic signaling pathways. The inactivation of the NF1 gene leads to diminished neurofibromin levels and thus to cell proliferation and tumor development.

**Diagnostic Criteria**

Distinctive findings of this disease are outlined in Table 1; two or more of the listed features are needed to diagnose NF1. Thus, the requisite findings corroborating NF1 include the following seven items: 1) the presence on an individual’s skin of six or more café-au-lait spots, that is, flat, rounded areas of hyperpigmentation, usually with irregular borders, each with a diameter greater than 5 mm (in prepubertal individuals) or greater than 15 mm (in postpubertal individuals). Café-au-lait spots can be seen in the newborn, and 95% of patients with NF1 have these spots by adulthood. In a review of 279 pediatric patients with NF1 published by Boulanger and Larbisseau, café-au-lait spots were found in 277 patients (99.3%).

2) Another criterion for the diagnosis of NF1 is skinfold freckling in the regions of the groin or axilla, and this was found in 59 (21.1%) of the aforementioned 279 pediatric patients with NF1. Others have found the incidence of groin or axillary freckling to be as high as 56 and 89%, respectively, in adult patients with NF1.

3) An additional diagnostic feature of NF1 is the presence of a distinctive osseous lesion. This lesion may manifest, for example, as sphenoid dysplasia or thinning of a
long bone cortex with or without pseudarthrosis. Boulanger and Larbrisseau\(^9\) documented the finding that, of the 279 pediatric patients with NF1 in their series, sphenoid and lambdoid dysplasias were present in 17 (6.1%) and three (1.1%) patients, respectively, and pseudarthrosis was noted in 10 (3.6%).

Other skeletal abnormalities in addition to the aforementioned distinctive osseous lesions can occur in patients with NF1. Thus, these patients are often of short stature, with a height below the 10th percentile for the patient’s age, and may also present with macrocrania, defined as a cranial perimeter above the 97th percentile.\(^{10,11,41,42,57}\)

Three other diagnostic criteria for NF1 include the presence of tumors that are characteristic for this disease. 4) Thus, common findings in NF1 include Lisch nodules, which develop in 95% of patients with NF1.\(^{44}\) These lesions are actually benign melanocytic hamartomas of the iris, and are usually multiple.

Low-grade astrocytomas occur in 15 to 20% of children with NF1 and typically involve the optic pathway.\(^{4,5}\) The presence of an optic glioma constitutes another of the clinical diagnostic criteria indicating NF1. It should be noted that malignant gliomas occur in only 2% of patients with NF1.\(^{42,47}\)

6) Individuals with NF1 also may harbor numerous neurofibromas and plexiform neurofibromas, which are representative of the NST category of neoplasias, and are the focus of this paper.\(^{44}\)

Neurofibromas arise from Schwann cells and exhibit an additional admixture of perineurial cells and fibroblasts.\(^{84}\) They present as three clinically and histologically distinct types, as follows:\(^{42,88}\) 1) cutaneous neurofibromas, which are discrete, benign tumors found within the dermis in more than 95% of patients with NF1, appear during preadolescence in these patients, and have no malignant potential; 2) nodular neurofibromas, which arise in peripheral nerves and may present as dumbbell-shaped intraforaminal spinal tumors; and 3) plexiform neurofibromas (Fig. 4), which were found to occur in 30% of 135 patients with NF1 who participated in a population study in southeast Wales detailed in a paper by Huson et al.\(^{29,45,46}\) In the Boulanger and Larbrisseau\(^9\) study of 279 patients, 107 (38.4%) and 69 (24.7%) of the pediatric patients had dermal/cutaneous and plexiform neurofibromas, respectively.

The second and third categories of neurofibromas associated with NF1, that is, nodular and plexiform tumors, are the NSTs that we will discuss here. It is important to note that the dictum that 6) the presence of two or more neurofibromas of any of the three types described, or one plexiform neurofibroma, is one of the seven categories of clinical diagnostic criteria indicating NF1, the last being that 7) a first-degree relative (parent, sibling, or offspring) has NF1 according to the first six criteria outlined.

Plexiform neurofibromas are associated with yet another NST of NF1: they can exhibit transformation into malignant PNSTs, and do so at the rate of 2 to 5%.\(^{24,30}\) None of the 69 pediatric patients (24.7%) with plexiform neurofibromas in the study by Boulanger and Larbrisseau,\(^9\) however, exhibited such a transformation. Neurofibromas of the plexiform type tend to be invasive and are characterized by longitudinal growth along multiple fascicles and branches of nerves, resulting in a “bag of worms” appearance. Fifty percent of plexiform neurofibromas tend to occur in the head, neck, face, and larynx.\(^{89}\) Plexiform neurofibromas in these and other regions, such as the lower extremities (although the latter locations are rare)\(^{86,73}\) can result in cosmetic deformities and functional deficits.\(^{90}\) Histologically, these lesions are NSTs and contain all the elements of the peripheral nerve. On microscopic examination, they are characterized by an increase in endoneurial matrix with separation of nerve fascicles and proliferation of Schwann cells.\(^{89,90}\)
Wilms tumors, pheochromocytomas, and neuroblastomas also occur in NF1 patients. Aqueductal stenosis with hydrocephalus also occurs in NF1 patients and is an indication of NF1. In a recent review of NF1, patients with NF1-associated malignancies developed. Because of this condition, the patient was unable to sit in a wheelchair due to severe pain. Kyphoscoliosis is a frequent complication associated with NF1.

**Other NF1 Manifestations**

Non–neural sheath NF1-associated tumors include lesions of the small intestine, Wilms tumors, pheochromocytomas, and juvenile chronic myeloid leukemias. There is a report of an intrathoracic vagus nerve neurofibroma as well. Mental retardation, or an intelligence quotient less than 70, occurs only slightly more frequently in patients with NF1 than in the general population. Fifty percent of patients with NF1, however, present with learning disabilities and/or many with attention deficit disorder, the latter according to criteria outlined by the American Psychiatric Foundation. According to Boulanger and Larbisseau, mental retardation was found in 17 (6.1%) of their 279 pediatric patients with NF1, attention deficit disorder was found in 113 (40.5%), developmental delays in 71 (25.4%), and learning disabilities occurred in 85 (39%) of the 218 school-age children. These authors stated that developmental delays should be divided into three categories: global, isolated speech, or isolated motor delays, and to be relevant, should be present during two subsequent pediatric neurological evaluations. Also, they note that when interviewing the patient and family, if the child is of school age, the physician should document whether the patient fits one of the following categories: 1) was placed in a special class or school or was determined to need this by the neuropsychologist; 2) failed a class or year; or 3) was in the lower rank of a class for more than 1 year. A panoply of other disorders can also arise in patients with NF1, and these encompass endocrine dysfunction such as GH deficiency and central precocious puberty in the absence of optic chiasm gliomas. Hypertension occurs frequently in patients with NF1, and it should be noted if the blood pressure is above the 95th percentile for the patient’s age. Aqueductal stenosis with hydrocephalus also occurs in these patients. Differences exist in the literature, however, regarding the incidence of aneurysms associated with NF1. There are 23 case reports documenting an association, whereas other clinical studies have not shown this connection.

**Malignant PNSTs in NF1**

Malignant PNSTs, also called malignant schwannomas or neurogenic sarcomas, are sarcomas that arise from the sheath of Schwann surrounding peripheral and some central nerve fibers. Most patients with NF1-associated malignant PNSTs are younger, that is, in their second and third decades of life, than patients with malignant PNSTs in the general population. Regarding histological findings, malignant PNSTs exhibit hypercellularity, increased mitotic activity, necrosis, and cytological atypia. These tumors, however, may show greater order in some cases associated with NF1. In NF1 cases in which dedifferentiation has occurred, the cells may have features suggesting a malignant fibrous histiocytoma. The neural lesions in these cases, however, have a varying degree of S100 protein positivity.

Malignant transformation of neurofibromas occurs in 2 to 5% of patients with NF1 compared with an incidence of 0.001% in the general population. In a recent review of 397 PNSTs treated at Louisiana State University Health Sciences Center, of 28 patients with neurogenic sarcomas of the brachial and pelvicplexuses and major peripheral nerves, 12 (43%) were found in individuals with NF1. Malignant PNSTs are also associated with more frequent local recurrences and metastases in patients with NF1, and the survival rate is also worse. The results of the study by Cashen, et al., however, differed with regard to lower survival rates. In their series of 80 patients with malignant schwannomas, most had Stage II tumors according to the Musculoskeletal Tumor Society grading scale. That is, high-grade lesions, but not metastasized, and 10 of the patients had metastases at the outset (Stage III). Overall, the

<table>
<thead>
<tr>
<th>TABLE 1 Clinical diagnostic criteria indicating NF1*</th>
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<tr>
<td>≥6 café-au-lait macules ≥5 mm in greatest diameter in prepubertal individuals or ≥15 mm in greatest diameter in postpubertal individuals</td>
</tr>
<tr>
<td>Freckling in the axillary or inguinal regions</td>
</tr>
<tr>
<td>Distinctive osseous lesion such as sphenoid dysplasia or thinning of a long bone cortex w/ or w/o pseudarthrosis</td>
</tr>
<tr>
<td>≥2 neurofibromas of any type or ≥1 plexiform neurofibroma</td>
</tr>
<tr>
<td>1st-degree relative (parent, sibling, or offspring) w/ NF1 by these criteria</td>
</tr>
</tbody>
</table>

* An individual is affected with NF1 if two or more of the following clinical features are present. Modified from Neurofibromatosis. National Institutes of Health Consensus Statement Online 1987 July 13–15 (cited 2005 November 13); 6(12):1–19.
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80 patients had a survival rate of 85% at 11 ± 5 years, and there was no difference between the outcome statistics for tumors arising spontaneously and those occurring in patients with NF1. In this study, the patient’s sex was not a factor in survival; however, the tumor stage was a notable determinant. Anatomical location also had a significant effect; patients whose tumors were located peripherally had a markedly higher rate of survival. In the study by Cashen, et al., the largest numbers of tumors were seen in the thigh, shoulder, and pelvis, but they also occurred in the abdomen and thorax, and distally in the forearm, hand, and foot.

Examination of Patients With NF1 and an NST

Key features of the history relevant to NSTs in patients with NF1 that must be documented include the tumor’s growth rate, location, and size, as well as mobility and any localized tenderness on palpation; a rapidly growing, deep, or painful lesion is suggestive of a malignant tumor. The presence or absence of the Tinel sign should also be assessed; however, this sign is frequently present in both benign and malignant tumors. Neurofibromas more commonly present with pain, whereas in schwannomas the incidence of pain as the initial presentation is less common. Motor deficits and sensory alterations should be evaluated; however, the NST may present as an asymptomatic incidental finding.

Imaging Findings in NF1

Magnetic resonance imaging is the most important modality in the evaluation of NSTs to determine the location, margins, and relationships of the tumors to adjacent structures. The advent of MR neurography has been useful in differentiating between intraneurial and perineural masses. Hyperintense or “unidentified bright objects,” that is, lesions in the basal ganglia, thalamus, cerebellum, and brainstem, may be found on T2-weighted MR images of the brain in patients with NF1.42,52,62 As stated, aqueductal stenosis with hydrocephalus also occurs more commonly in these patients and should be anticipated on MR imaging.77 As noted earlier, differences exist in the literature regarding the incidence of aneurysms in patients with NF1. Moyamoya disease occurs with NF1, as do optic gliomas and neurofibrosarcomas, and imaging is helpful for revealing these as well as for the evaluation of NF1-associated scoliosis.

Plain x-ray films, CT scans, and angiography still play useful roles in the evaluation of NF1-associated NSTs in selected cases. Chest x-ray films can sometimes depict lower plexal tumors. Plain x-ray films of the cervical spine may show evidence of intervertebral foraminal enlargement or vertebral erosion. Angiographic studies of vascular NSTs determine the degree of vascularity and delineate feeding vessels surrounding the tumor.

On MR imaging, according to Huang and colleagues,43 neurofibromas show a low to intermediate signal intensity on T1-weighted sequences, and a hyperintensity on T2-weighted ones (Table 2).40,44 Alternatively, a hyperintense peripheral rim with a low signal intensity focus, called a target sign, may be seen on T2-weighted MR images. Inhomogeneous enhancement occurs on studies obtained using gadolinium contrast.

On nonenhanced CT scans, neurofibromas are seen as well defined and hypodense relative to muscle, with attenuation values of 20 to 25 Hounsfield units.69 The low density may be caused by the high lipid content of the Schwann cells, but it may also be caused by cystic myxomatous degeneration or confluent areas of hypocellularity.31,69,71 Neurofibromas tend to have a dumbbell shape and cause visible bone erosion. With addition of contrast materials, neurofibromatous lesions demonstrate homogeneous enhancement on CT scans, with attenuation values of 30 to 35 Hounsfield units.

Spinal tumors have been found on MR images in 35.7% of patients with NF1. Thus, MR imaging screening of the spine has been suggested for patients with this disease.25,50 Other authorities do not advocate routine MR imaging, but instead suggest that such investigations should be dictated by clinical need.99,59

Malignant schwannomas exhibit a low signal intensity that is hypointense to muscle; on the other hand, they are bright on T2-weighted MR images. These lesions usually do not have a fibrous capsule, but instead extend into the adjacent soft tissue and muscle layers. With addition of gadolinium contrast, inhomogeneous enhancement is seen. On CT scans, malignant PNSTs are hypodense and ill defined, with enhancement of the margins. In patients with suspected malignant PNSTs, the metastatic workup should include

<table>
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<tr>
<th>Tumor Type</th>
<th>MRI T1-Weighted</th>
<th>MRI T2-Weighted</th>
<th>W/ Gd</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurofibroma</td>
<td>Low to intermediate</td>
<td>Hyperintense or hyperintense rim w/ low signal intensity focus (target sign)</td>
<td>Inhomogeneous enhancement</td>
<td>Well-defined, hypodense relative to muscle; dumbbell shape w/ bone erosion</td>
</tr>
<tr>
<td>Schwannoma</td>
<td>Intermediate signal intensity (isointense to muscle)</td>
<td>Hyperintense or isointense to muscle</td>
<td>Uniform enhancement for small tumors; heterogeneous enhancement for large tumors</td>
<td>Well-defined, oval or circular shape; isodense or hypodense to muscle; bone erosion</td>
</tr>
<tr>
<td>Malignant PNSTs</td>
<td>Low signal intensity (hyperintense to muscle)</td>
<td>Hyperintense to muscle</td>
<td>Inhomogeneous enhancement</td>
<td>Hypodense, ill-defined, w/ marginal enhancement</td>
</tr>
</tbody>
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* Adapted from Expert Rev Neurotherapeutics 5(4):515–523, 2005 with permission of Future Drugs, Ltd. Minor modifications have been made for style consistency.
lung and abdominal CT scans and liver, spleen, and bone scans obtained using technetium contrast materials.

Electromyography is another useful examination that should be performed in patients with NF1-related NSTs.

Surgical and Adjuvant Treatment for NSTs and Malignant PNSTs

In a study of 39 patients with 49 head and neck plexiform neurofibromas conducted by Wise, et al., complete resection was possible only in patients with small tumors. These investigators advised that surgery be performed on plexiform neurofibromas of the head and neck regions to accomplish the following objectives: 1) exclude malignancy in a rapidly enlarging mass; 2) provide relief from neurogenic pain or motor weakness; 3) improve symptoms caused by airway compression; or 4) enhance cosmesis in those with disfiguring disease. According to Wise, et al., methotrexate and vinblastine are used to slow or stop progression of existing disease. The rationale for their use is that desmoid tumors are similar to plexiform neurofibromas with respect to their aggressive fibromatosis, and several small studies have shown favorable results when this combination of agents is used on desmoid tumors. Interferon-α, an antiinflammatory and antiangiogenic agent, or cis-retinoic acid, a pro-maturation agent, were found to stabilize tumor growth after 18 months in 96% of children and 86% of adults with plexiform neurofibromas in a study conducted at the Children’s Hospital in Philadelphia.

Other Phase I studies have been performed to evaluate farnesyl protein transferase inhibitors, which block post-translational isoprenylation of ras and inhibit ras activity. Pirfenidone, or 5-methyl-1-phenyl-2p-(1-H)-pyridine, a broad-spectrum antibiotic drug that modulates cytokine action, is presently being used in clinical trials in adults with progressive plexiform and spinal neurofibromas. Another Phase I open-label study in which thalidomide was used to reduce angiogenesis has recently been completed. In that study, four of 17 patients experienced a 25% reduction in tumor size.

In contrast to symptomatically benign NSTs, in which surgical extirpation is the main therapy, adjuvant treatment...
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Fig. 6. Sagittal MR image of the spine demonstrating a T10–11 schwannoma in a patient with NF2.

plays a crucial role for malignant PNSTs. In a study performed by Cashen, et al.,\textsuperscript{13} in 80 patients with malignant PNSTs, all patients were treated after the mid-1970s, and thus half received adjunctive treatment and 28% (22 patients) underwent preoperative chemotherapy, which included adriamycin, ifosfamide, and other agents, along with radiation therapy in many cases. This treatment seems to have improved the outlook for patients with large soft-tissue sarcomas, including patients with malignant schwannomas.

**Hormone Receptors in NF1 Tumors**

Localized neurofibromas increase in both number and size during adolescence and also during pregnancy in patients with NF1.\textsuperscript{22} In a study by McLaughlin and Jacks\textsuperscript{58} of progesterone and estrogen receptors in 59 neurofibromas, 36 of which were obtained in patients with NF1, the majority (75%) of all neurofibromas expressed progesterone receptors and only 5% expressed estrogen receptors. Within the neurofibromas, progesterone receptors were expressed by non–neoplastic tumor–associated cells and not by neoplastic Schwann cells. Antiprogestins may thus be useful in the treatment of this tumor.

In the past few years, GH has been identified as a potent inducer of cell growth in many different tumors.\textsuperscript{12,22} Because GH concentrations increase during adolescence, paralleling the size of neurofibromas in patients with NF1, it is possible that GH is one of the influences on their growth. As stated earlier, it is known that Schwann cells in neurofibromas obtained in patients with NF1 have high concentrations of the activated form of the ras protein (ras–guanosine 5′-triphosphate). This occurs because neurofibromin, an important regulator of the ras pathway, is modified as a consequence of mutation of the NF1 gene.\textsuperscript{78} It is possible that neurofibroma cells have increased ras–guanosine 5′-triphosphate concentrations because of the action of GH as well, which helps facilitate an increase in cell number. This could explain the size increase of localized neurofibromas during adolescence in patients with NF1. The increase of GH secretion seen in this period could be another factor resulting in the superstimulation of the ras protein–signaling pathway in neurofibroma cells.\textsuperscript{22}

Growth hormone exerts a wide variety of biological actions in many different tissues and cell types, which can be divided into three categories: those affecting mitogenesis, differentiation, and metabolism. The ability of GH to promote its various effects is dependent on its interaction with membrane receptors in target tissues. The activation of the GH receptor by the hormone is responsible for initiation of a variety of signaling pathways. These include pathways involving a signal transducer and activator of transcription, ras–mitogen activated protein kinase, and insulin receptor substrate.\textsuperscript{12,22} Cunha, et al.,\textsuperscript{22} found that six of 16 patients without NF1 who had solitary neurofibromas and nine of 10 patients with NF1 who had localized neurofibromas were immunopositive for GH receptors.

**NEUROFIBROMATOSIS TYPE 2**

**Incidence and Genetics**

Neurofibromatosis Type 2 occurs much less frequently than NF1, that is, in 1 in 33,000 births.\textsuperscript{43} Mutations in NF2 occur on 22q12 and result in the inactivation of the tumor suppressor merlin.\textsuperscript{43,73,85}

**Diagnostic Criteria**

The criteria for NF2 (Table 3) include bilateral eighth cranial nerve masses seen with appropriate imaging modalities, including either CT or MR imaging. Neurofibromatosis Type 2, however, is most classically represented by bilateral eighth cranial nerve schwannomas, which occur in more than 95% of cases (Fig. 5).\textsuperscript{43,57} Another clinical diagnostic criterion indicating NF2 is a first-degree relative with NF2 and either a unilateral eighth cranial nerve mass or two of the following: neurofibroma, meningioma, glioma, schwannoma, and juvenile posterior subcapsular lenticular opacity.

**Other NF2 Manifestations**

Whereas NF1 is characterized by multiple cutaneous and subcutaneous neurofibromas, in NF2, multiple schwannomas of intracranial and spinal nerves are characteristic. Spinal schwannomas (Fig. 6), however, are also prevalent in patients with NF2, as are non-NSTs such as meningiomas.\textsuperscript{43,56,61}

**Malignant PNSTs in NF2**

Spontaneous transformation of a schwannoma to a malignant PNST does occur, although infrequently; the background rate of 0.5% for central nervous system malignant-
Clinical diagnostic criteria indicating NF2*

**bilat 8th cranial nerve masses seen w/ appropriate imaging techniques (for example, CT or MRI) or**
1st-degree relative w/ NF2 & either:
- unilat 8th cranial nerve mass,
- or
- 2 of the following:
  - neurofibroma
  - meningioma
  - glioma
  - schwannoma
- juvenile posterior subcapsular lenticular opacity


**cy in patients with NF2 is much lower than that observed in patients with NF1.**

**Examination of Patients With NF2 and an NST**

The examination details are the same as those presented for the patient with NF1. It should be reiterated that NF1-related neurofibromas more commonly present with pain, whereas in NF2-associated schwannomas, the incidence of pain as the initial presentation is less common.

**Imaging Findings in Patients With NF2**

On T2-weighted MR images, schwannomas have an intermediate signal intensity, which is isointense to muscle (Table 2). On T2-weighted images the schwannoma appears hyperintense or isointense to muscle. With addition of gadolinium contrast material there is uniform enhancement for small tumors and heterogeneous enhancement for large ones. On CT scans, the schwannoma has a well-defined oval or circular shape and is isodense or hypodense to muscle. Bone erosion is often exhibited. Malignant PNSTs in patients with NF2 exhibit the same features as those described for these lesions when they are associated with NF1.

**CONCLUSIONS**

Neurofibromatosis 1 and 2 are diseases with numerous sequelae of which the neurosurgeon must be aware, because many of the associated conditions require neurosurgical intervention.

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malignant peripheral nerve sheath tumors in neurofibromatosis


currence of multiple abdominal and cerebral vascular abnormalities.] Rofo 126:218–227, 1977 (Ger)


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