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Pediatric and Adolescent Oligodendrogliomas

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PURPOSE: To review the clinical and imaging findings in pediatric and adolescent intracranial pure oligodendrogliomas. **METHODS:** The clinical, CT, and MR data in 39 surgically proved pure oligodendrogliomas were retrospectively reviewed. **RESULTS:** The frontal or temporal lobes were involved in 32 (82%) cases. Seventy percent of the tumors were hypodense on CT, three-fourths were hypointense on T1-weighted images, and all were hyperintense on spin-density and T2-weighted images. Fewer than 40% of the lesions demonstrated calcification, and nearly 60% had well-defined margins. Mass effect was seen in fewer than half of the cases, and edema could be separately identified in only one case. Tumor enhancement was seen in fewer than 25%. In 39 cases after partial (3), subtotal (16), or total (20) resection, follow-up studies demonstrated stability over a mean period of 5 years. **CONCLUSION:** The findings in this pediatric series of pure oligodendrogliomas (without mixed cell elements) differ from previous adult series in that calcification, contrast enhancement, and edema are seen less frequently. In addition, very slow or no growth is often characteristic, and these patients have an excellent prognosis with surgical resection.

Index terms: Oligodendroglioma; Brain, occipital lobe; Brain neoplasms, computed tomography; Brain neoplasms, magnetic resonance; Brain neoplasms, in infants and children; Pediatric neuroradiology

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Oligodendrogliomas comprise 4% to 7% of all primary intracranial gliomas (1). The recent literature discusses this tumor in mixed adult and pediatric patient population groups or in several mixed tumor groups pathologically (1–12). The purpose of this study was to review the clinical and imaging findings in a large number of pediatric and adolescent patients with pathologically proved pure oligodendrogliomas.

Materials and Methods

The clinical and imaging studies of 39 patients with proved pure oligodendrogliomas were reviewed retrospectively (Table 1). There were 21 boys and 18 girls. The age at presentation ranged from 2 to 17 years with a mean age of 9.8 ± 5.2 years. Tumors of mixed histology were excluded. Clinical information recorded in all patients included presentation, course, and the length of time from initial imaging to surgery.

Computed tomography (CT) was available before surgery in 37 cases. All of the studies were done with axial 5-mm- or 10-mm-thick sections before and after intravenous iodinated contrast administration. Direct coronal sections were done in five cases. Contrast-enhanced studies in 33 patients were available for review. Magnetic resonance (MR) of the original tumor was available in 11 cases. Both CT and MR were available in 10 patients before surgical resection.

All MR examinations were done using a 1.5-T system. Gadopentetate dimeglumine (Magnevist; Berlex Inc, Wayne, NJ) was given intravenously (0.1 mmol/kg) for five MR examinations. Sagittal T1-weighted studies (600/20/2) (repetition time/echo time/excitations) were done, followed by axial and coronal spin-density and T2-weighted studies using conventional spin-echo techniques (2000/30–80) supplemented with fast spin-echo sequences (2000/15–90) in some cases. Section thickness was 5 mm with a 1.0- to 2.5-mm intersection gap and a 256 × 128 or 256 × 192 matrix. Postcontrast T1-weighted images were done in sagittal, axial, or coronal planes using the above parameters.

Postoperative follow-up examinations were available in all 39 patients. CT was the only modality used in following 26 patients; MR was the sole modality in two patients. Both

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TABLE 1: Clinical findings

39 Patients: 21 boys, 18 girls	
Mean age at presentation	9.82 ± 5.2 years
Age range	2–17 years
Symptoms	
Seizures	33/39 (85%)
Headache	8/39 (21%)
Increased intracranial pressure	4/39 (10%)
Precocious puberty	1/39 (3%)
Visual field defect	1/39 (3%)

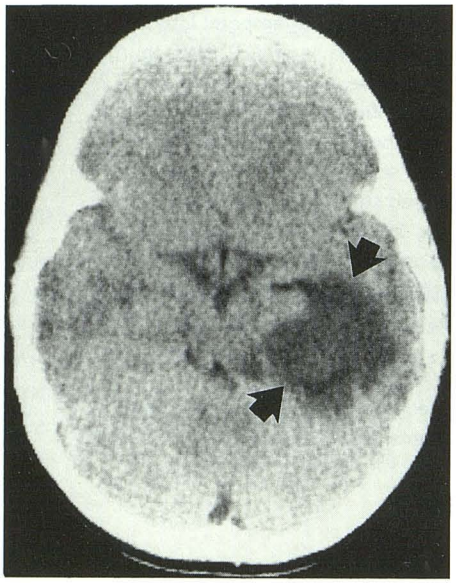
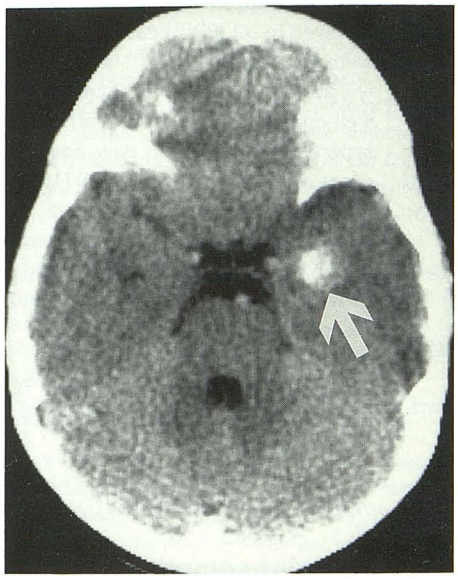


Fig. 1. Three-year-old boy with focal seizures. Nonenhanced CT demonstrates a well-defined low-density left temporal lobe lesion (*arrows*) without evidence of calcification. No abnormal enhancement was demonstrated, and there was minimal mass effect.

CT and MR examinations were used to follow patients in nine cases. All studies were reviewed by two neuroradiologists in a nonblinded fashion. The CT and MR parameters studied and correlated with surgical findings were size, location, margins, density, intensity, calcification, enhancement, edema, mass effect, and hydrocephalus.

Results

Seizure was the most common clinical manifestation occurring in 33 patients (85%), followed by headache in eight cases (21%) and symptoms and signs of increased intracranial pressure in four (10%). Seizure was the only manifestation in 31 patients. Headache as the only symptom occurred in one patient. Combined clinical symptoms and signs were present in eight patients, including two with seizure and headache, one with precocious puberty and gelastic seizures, one with headache and visual-field deficit, and four with headache, emesis, and papilledema (increased intracranial pressure). In all 33 patients with seizures, there were clinical or electroencephalogram findings of focality. In 32 cases, information was available about the length of time patients were followed before undergoing surgical resection. A mean interval of 1.61 ± 2.2 years was found, with a range of 1 month (minimal period of time) to 8 years. Five of 32 cases (16%) were followed without progression for a minimum of 4 years before surgical resection.



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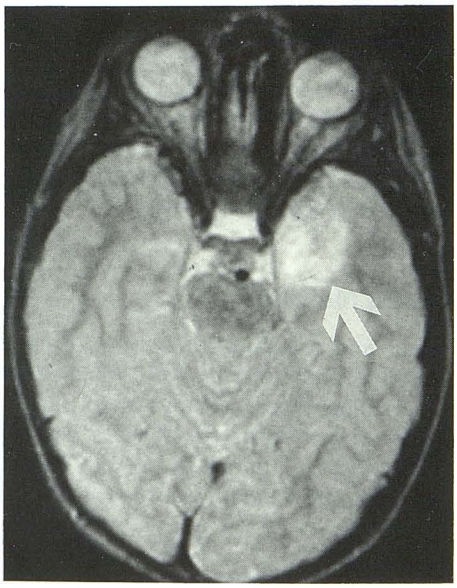

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Fig. 2. Six-year-old boy with focal seizures. Nonenhanced CT (*A*) demonstrates a calcified, left-temporal lobe tumor (*white arrow*). No abnormal enhancement was evident. Axial T2-weighted MR (*B*) demonstrated nodular high intensity (*white arrow*).

The frontal or temporal lobes (Figs 1, 2, and 3) were involved in 32 patients or 82% of the total cases (Tables 2 and 3). Primary or additional involvement of the parietal or occipital lobes (Fig 4) was present in four. All of the patients with cerebral lobar tumors presented primarily with seizures (17 temporal lobe, 10 frontal lobe, two parietal lobe, one frontotemporal, one frontoparietal, one parietooccipital, and one hypothalamic) or headaches (two temporal lobe, one lateral intraventricular, and one temporparietal occipital). There were two patients with primary involvement of the hypothalamic and third ventricular structures. They presented with a combination of symptoms and signs including headache, emesis, and papilledema (hydrocephalus) in two and precocious puberty and gelastic seizures in one. One patient with a posterior fossa tumor presented with hydrocephalus (Fig 5). Another patient with a right lateral intraventricular tumor presented with unilateral headaches (Fig 6). One patient had primary leptomeningeal involvement (oligodendrogliomatosis) with symptoms and signs of increased intracranial pressure (Fig 7). Another patient with seizures and a primary temporal lobar tumor subsequently developed leptomeningeal dissemination.

Seventeen lesions were right-sided, 17 left-sided, three midline, and two diffuse (Tables 2 and 3). The mean greatest diameter of the tumors in our study was 3.44 ± 2.02 cm with a range of 0.5 to 10 cm. Lesion margins were classified as well defined in 21 cases (57%) and ill defined in 16 cases (43%). On CT (Table 2), the lesions were low density (26 cases) in the majority (70%) of cases (Figs 1, 3, and 4). Seven tumors (19%) were of high density (Fig 2), and three (8%) were isodense. One lesion demonstrated mixed low and high attenuation (Fig 5). On MR, eight of 11 lesions (73%) were hypointense relative to white matter on T1-weighted images (Figs 4 and 6),

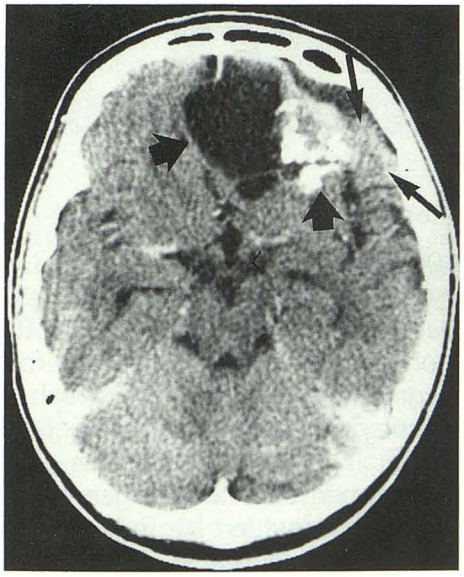


Fig. 3. Fifteen-year-old girl with focal seizures. Contrast-enhanced CT demonstrates a bifrontal well-defined low-density and calcified mass (*block arrows*). There is minimal enhancement (*long arrows*).

TABLE 2: Imaging findings

Tumor diameter	
Mean	3.44 cm
Range	0.5–10 cm
Lesion margins	
Well-defined	21/37 (57%)
Ill-defined	16/37 (43%)
CT density	
Low	26/37 (70%)
High	7/37 (19%)
Intermediate	3/37 (8%)
Mixed	1/37 (3%)
MR T1 signal intensity	
Hypointense	8/11 (73%)
Hyperintense/mixed	3/11 (27%)
MR T2 signal intensity	
Hyperintense	11/11 (100%)
Calcification	
CT	14/37 (38%)
MR	4/11 (36%)
Enhancement	
CT	8/33 (24%)
MR	4/5 (80%)
Edema	
CT	0/37 (0%)
MR	1/11 (9%)
Mass effect	
CT	14/37 (38%)
MR	5/11 (45%)
Hydrocephalus	5/37 (13%)
Trapped temporal horn	3/37 (8%)
Hemorrhage (MR)	1/11 (9%)

TABLE 3: Frequency and location of oligodendrogliomas

Location of Oligodendrogliomas	Number
Frontal	11
Temporal	18
Temporo-parieto-occipital	1
Fronto-temporal	1
Fronto-parietal	1
Parietal	1
Parieto-occipital	1
Hypothalamus/third ventricle	2
Posterior fossa	1
Intraventricular	1
Leptomeningeal	2[a]

[a] One patient had a primary temporal lobe tumor and subsequently developed dissemination.

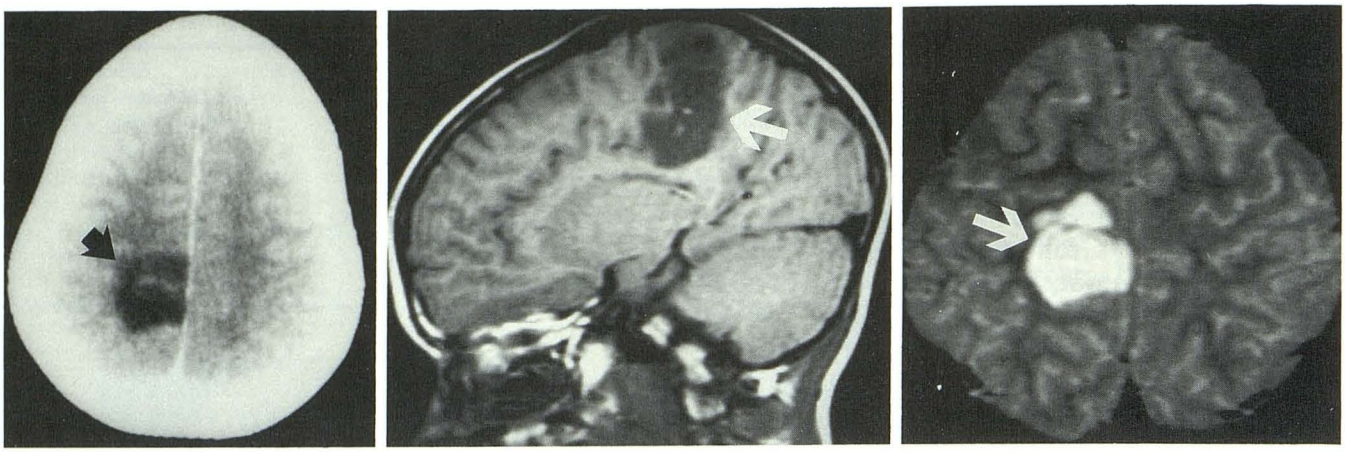


Fig. 4. Six-year-old boy with focal sensory seizures and left foot paresis. Contrast-enhanced CT (*A*) shows a well-defined low-density, nonenhancing right parietal tumor (*black arrow*). The tumor (*white arrow*) is hypointense on the sagittal T1-weighted MR (*B*) and hyperintense on the axial T2-weighted MR (*C*).

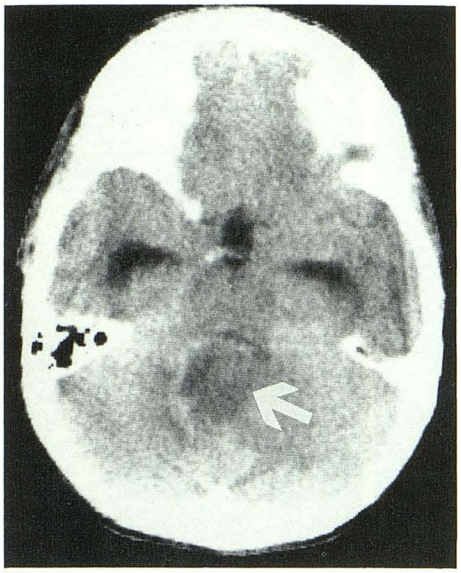
and three of 11 (27%) were hyperintense or of mixed intensity (Table 2). All lesions were hyperintense relative to white matter on the proton density and T2-weighted images (Figs 2, 4, and 6).

In this series, 14 of 37 (38%) demonstrated calcification on CT (Figs 2, 3, and 6). By MR, calcification was detected in three of 11 cases (Fig 6) and suggested in one additional case (36% total). On CT, 24% of the tumors (eight of 33) demonstrated iodine enhancement (Figs 5 and 7), whereas on MR, 80% (four of five) demonstrated gadolinium enhancement (Fig 6). In two patients, both iodine and gadolinium enhancement were demonstrated. The degree of enhancement was minimal to mild in five and moderate in two. Marked enhancement was seen in three cases. Only five cerebral lobar tumors demonstrated enhancement, and in only one was the enhancement described as marked in degree. Of the other five tumors showing enhancement, one each was located in the posterior fossa, the third ventricular region, and the right lateral ventricle, and two were disseminated tumors (oligodendrogliomatosis) showing marked enhancement (Fig 7). Separate identification of edema was not made by CT in any of the 37 cases; in only one of 11 cases was it made by MR. Mass effect ranging from mild to severe was seen in 14 of 37 cases (38%) on CT and five of 11 (45%) on MR. Hemorrhage was suggested in one case on MR. Hydrocephalus was demonstrated in five cases, and tumor trapping of the temporal horn was shown in three. Cysts were not identified in any case.

Twenty cases underwent total surgical resection, 16 were subtotally resected, and three were partially resected or biopsied. The mean interval follow-up was 5.06 ± 3.70 years with a range of 4 months to 15 years. In all 39 cases, no progression of tumor was demonstrated postoperatively. Nineteen of 39 cases (49%) demonstrated stability on follow-up of at least 5 years, and six of the 19 were followed for 10 years or more without change. In one patient who was followed for 3 years before surgical resection, the neoplasm then became progressive at which time it was subtotally resected. The patient has remained stable for four years. Stable residual abnormalities included surgical or radiation changes in three patients. Stable quiescent or inactive residual neoplasm could not be definitively excluded in many cases.

Discussion

In 1900, Robertson first recognized oligodendroglial cells as the myelin-forming unit of the neuroglial portion of the central nervous system (9). Oligodendrogliomas are neuroepithelial neoplasms composed of glial cells which resemble oligodendrocytes, and thus are classified as gliomas (13). The first descriptions of oligodendrogliomas appeared in a histogenetic classification of gliomas provided by Bailey and Cushing in 1926 (14) and in a report by Bailey and Bucy in 1929 when 13 cases were described (15). Most of these tumors reportedly occur in the cerebral hemispheres, usually in a cortical or subcortical location (16). The well-differentiated oligodendro-



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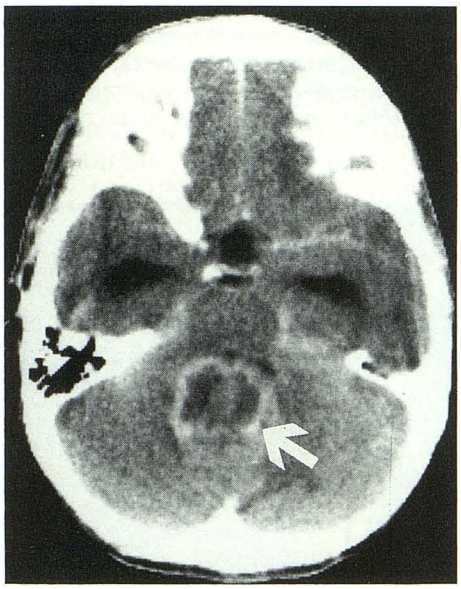

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Fig. 5. Fifteen-year-old boy with increased intracranial pressure. Pre- and postcontrast-enhanced CT (*A* and *B*) demonstrate a poorly defined midline posterior fossa tumor (*white arrows*) with mixed-density characteristics and irregular enhancement, along with hydrocephalus.

glioma is described as slow growing, may be circumscribed or infiltrative, shows microvascular proliferation, and is frequently calcified. Variant forms may be seen with abundant extracellular mucoid material, gross cysts, or hemorrhage, but edema is unusual. When they are cortical in location, they may erode the inner table of the cranial vault. A tendency for invasion and leptomeningeal dissemination has also been reported (16). Dense cellularity, prominent mitoses, vascular proliferation, and necroses characterize anaplastic oligodendrogliomas, which have a similar pathologic appearance to glioblastomas (13, 17).

Oligodendrogliomas often contain other glial elements, most often astrocytic, and approximately 50% of the tumors generally classified as oligodendrogliomas consist of mixed-cell forms (1). These are more appropriately classified as mixed gliomas. Mixed gliomas contain roughly equivalent portions of different glioma types, either as segregated areas or intermixed (17). The specific nomenclature for individual tumors is derived from the recognized components in descending order of prominence. One of the most common mixed gliomas is the oligoastrocytoma. Prognosis often depends on the more aggressive element.

We are aware of only one published report of the MR findings in a series of oligodendrogliomas in a patient population comprising all age groups (1). Previous studies reviewing oligodendrogliomas in childhood include Varma et al (18), who described the clinical and CT findings in three children with mixed oligodendrogliomas, and Nov et al (19), who described the clinical course and CT findings in three pediatric thalamic oligodendrogliomas. Other studies describe the imaging findings in adult or mixed (adult and pediatric) population groups (1–3, 5, 7, 9, 20).

As in a previous study, no gender predilection was demonstrated in this series. Seizure was the most common presenting symptom in this series, followed by headache, and both were associated with temporal lobe (21 cases) or frontal lobe (11 cases) involvement in more than 80%. The frequency of seizures as the presenting symptom is reported in previous studies as ranging from 24% to 100% (1, 4–6, 8, 9, 18). In another study (6), headache was the most frequent presenting symptom in 78% of 323 patients, although 70% also had seizures. Headache was the most common presenting symptom in 74% of intraventricular oligodendrogliomas (2). The patient with an intraventricular oligodendroglioma in this series presented with unilateral headache. Headache was the presenting symptom in a series of three pediatric thalamic oligodendrogliomas (19). Headache was the presenting symptom in three of four pediatric posterior fossa oligodendrogliomas described by Packer et al (20). In the one case of a posterior fossa oligodendroglioma in this series, the patient presented with headache related to hydrocephalus.

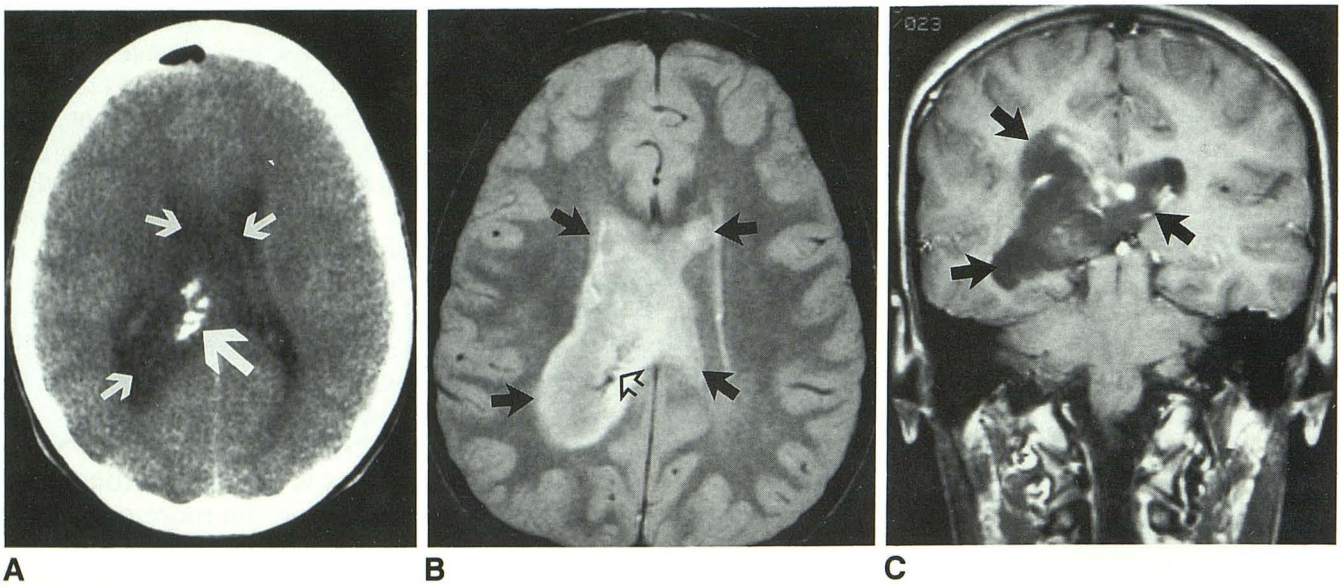

Fig. 6. Thirteen-year-old girl with right-sided headaches. Axial, nonenhanced CT (*A*) shows the poorly defined isodense intraventricular mass (*small white arrows*) and calcifications (*large white arrow*). A small amount of subdural air is present frontally after a biopsy. Axial proton density MR (*B*) demonstrated a right lateral intraventricular hyperintense mass (*black arrows*) expanding the ventricle and extending across the midline into the left lateral ventricle. Calcifications are also demonstrated (*open arrow*). Coronal enhanced T1-weighted MR (*C*) demonstrates the bilateral hypointense intraventricular tumor (*black arrows*) and mild to moderate nodular enhancement.

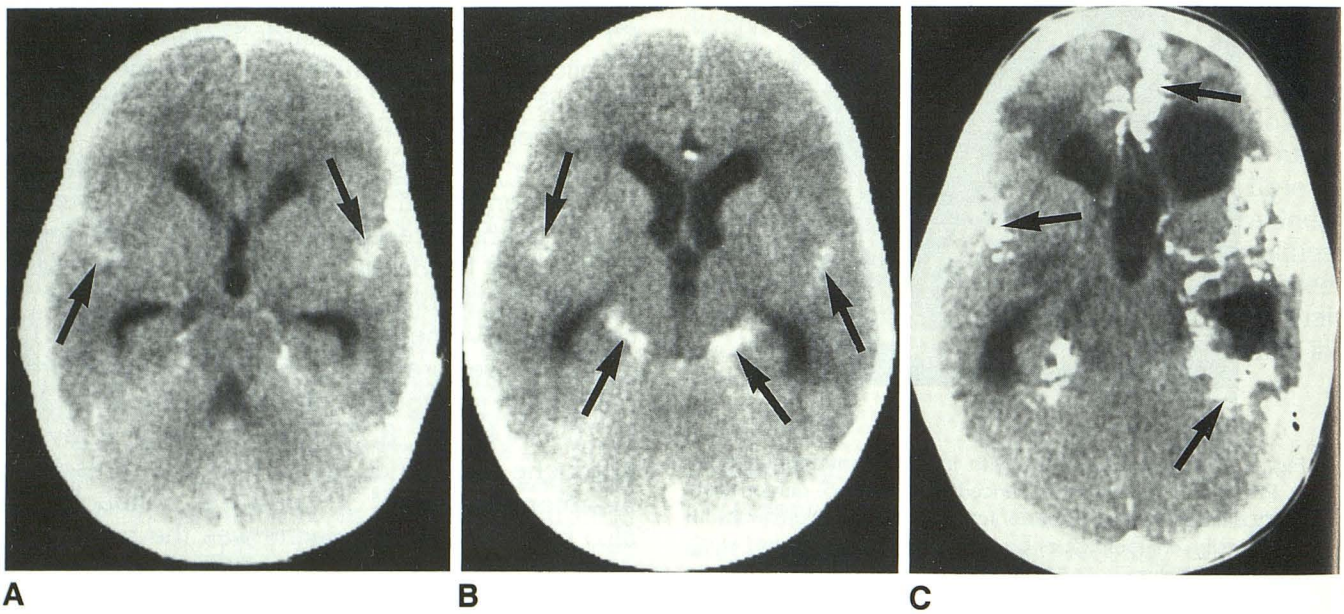

Fig. 7. Two-year-old boy with primary oligodendrogliomatosis and hydrocephalus. Contrast-enhanced CT (*A* and *B*) shows abnormal enhancement of the cisterns and fissures (*black arrows*) plus hydrocephalus. Follow-up axial nonenhanced CT study (*C*) 1 year after ventricular shunting, biopsy, and radiotherapy, shows extensive leptomeningeal calcification (*black arrows*).

The majority of lesions in this series involved the frontal or temporal lobes (Tables 2 and 3; Figs 1–3). In the series described by Lee and Van Tassel (1), the frontal lobes were involved in 69% of the cases, with the next most frequent site being the parietal lobe (20%). Frontal or temporal locations were noted in 67% to 73% of cases in other studies (3, 6, 18) and mentioned as the most common tumor location by other authors (5, 9, 15). In terms of lesion size at presentation, this study revealed a mean greatest diameter of 3.44 cm with a range of 0.5 to 10 cm (Table 2).

Lee and Van Tassel (1) described a size range of 2 × 2 × 2 to 6 × 6 × 7 cm. Tumor dimensions were not available in other published studies. In this series, lesion margins were well defined in 57% and ill defined in the remaining 43%. In other studies, tumor margins were well defined in 49% (1).

The majority of tumors (69%) in this series were low density on CT (Table 2; Figs 1, 3, and 4). Other studies describe low-attenuation characteristics in 57% to 100% of cases (1, 3, 7, 18). Less than half of the lesions in this series were calcified (Figs 2, 3, and 6). Previously reported percentages range from 10% to 91% of cases (1, 3, 5, 15, 18). Contrast enhancement was present in 24% of the tumors in this series (Table 2; Figs 5–7) compared with a range of 33% to 90% as reported in previous studies (1–3, 18). The identification of edema separate from tumor was often difficult, particularly on CT, because enhancement was infrequent. In only a single case was it speculated that edema (nonenhancing) was distinguishable from tumor (enhancing). In no case was a characteristic vasogenic edema pattern of white matter identified. In other studies, edema has been reported in 39% to 100% of cases (1, 18).

In this study, although the numbers for comparison are small, CT and MR were roughly equivalent in the detection of calcification, hydrocephalus, and mass effect. The equivalent detection of calcification by MR compared with CT in this series is contrary to prior experience but is probably related to the large size of the calcium deposits relative to voxel size and tumor volume (Fig 7). Also, edema and enhancement were more frequently appreciated with MR than with CT. Lesion location, size, margins, and CT density as observed in this study parallel those of previous reports. Many authors, however, do not describe mass effect or hydrocephalus as described in this series. The findings that calcification, contrast enhancement, and edema are seen less frequently in this series than in others may be related to differences in population and pathology. Furthermore, neither the CT nor MR findings are specific to distinguish oligodendroglioma from ganglioglioma, low grade astrocytoma, neurocytoma, or dysembryoplastic neuroepithelial tumor (21–23).

Most of the patients in this study returned after treatment. This allowed the unusual opportunity for long-term follow-up. All our patients demonstrated remarkable stability after partial, subtotal, or total resection of their tumors with nearly half remaining stable at the 5-year follow-up. Oligodendrogliomas are noted to be generally low grade tumors but may demonstrate more aggressive behavior, especially when there is mixed histopathology, for example, oligodendroglioma with astrocytic elements. The fact that the tumors in this series were oligodendrogliomas without mixed-cell forms may account for their very stable behavior on follow-up. It is also noteworthy that many lesions were followed for some time without progression before surgical resection. In most of these cases, the patients were closely followed clinically and radiologically, and surgery was delayed because of dominant hemisphere involvement, well-controlled seizures, and absence of neurologic deficits. In addition, some of the lesions were considered "likely benign" in nature. In one of these, the low-density temporal lobe lesion (Fig 1) was originally thought to possibly represent an arachnoid cyst.

In conclusion, the findings in this series of pediatric and adolescent intracranial pure oligodendrogliomas (without mixed-cell elements) differ from previously published adult and mixed population series of oligodendrogliomas (often mixed tumors). In the current series, calcification, contrast enhancement, and edema were seen less frequently. In addition, very slow or no growth was often characteristic, and these patients demonstrated an excellent prognosis with subtotal or total surgical resection of their tumors.

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