EVALUATION OF BRAIN TUMORS USING MAGNETIC RESONANCE IMAGING IN ADULT PATIENTS

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Abstract. *This descriptive and analytical study was carried out at the Republican Specialized Scientific-Practical Center of Neurosurgery between January 2023 and September 2023 to assess brain tumors using Magnetic Resonance Imaging (MRI). The study included a sample of 30 patients, both male and female, aged between 20 and 80 years, who were suspected of having brain tumors. The results indicated that the most affected age group was 40 to 60 years, accounting for 46.7% of cases, whereas the 60 to 80-year age group had the lowest prevalence at 16.7%. Female patients were more commonly affected than males, making up 53% of cases compared to 47% for males. Non-malignant tumors were the most prevalent, comprising 57% of cases. Among malignant tumors, 84.7% were classified as primary, while 15.3% were secondary. Meningioma was the most frequently observed tumor type on MRI, accounting for 43.3% of cases in both male and female patients.*

Keywords: *brain tumors, MRI, non-malignant tumors, meningioma.*

Introduction. A brain tumor is defined as a pathological proliferation of cells forming a mass within the intracranial compartment. These neoplasms can be categorized based on their biological behavior into benign (non-invasive, non-metastatic) and malignant (invasive, potentially metastatic) types. Brain tumors may arise de novo from neural or supporting tissues within the central nervous system, termed primary brain tumors, or they may represent secondary involvement due to hematogenous dissemination from extracranial primary malignancies, known as metastatic brain tumors. The growth rate of brain tumors varies significantly, and both the size and location of a tumor influence its impact on the nervous system, potentially leading to dysfunction in affected areas. Treatment options depend on several factors, including the tumor's type, location, and size [5].

Brain tumors represent a significant medical and societal challenge due to their complex nature and high morbidity. Malignant brain neoplasms, in particular, are associated with unfavorable clinical outcomes, exhibiting a five-year survival rate of approximately 35%. According to global cancer statistics, in 2020, there were an estimated 308,102 newly diagnosed cases of primary brain and central nervous system (CNS) tumors, resulting in 251,329 cancer-related deaths, underscoring their substantial global mortality burden [7].

The 2021 World Health Organization (WHO) Classification of CNS Tumors introduced significant changes in the diagnostic approach to brain tumors. This classification now integrates both histological and genetic factors, providing deeper insights into tumor prognosis and treatment strategies. However, these advancements also present challenges in diagnosing specific tumor subtypes [6,4].

Brain tumors are diagnosed using imaging techniques such as positron emission tomography (PET), computed tomography (CT), and magnetic resonance imaging (MRI), with MRI offering distinct advantages over other modalities. MRI provides detailed anatomical information, helping to determine the location, size, shape, and type of a tumor. However, manual interpretation by radiologists can be subjective, time-consuming, and prone to errors. Therefore, automated tumor detection methods using machine learning and advanced image processing are being explored to enhance early diagnosis [2].

Timely detection of brain tumors is essential for enhancing therapeutic efficacy and improving patient prognosis. A variety of imaging modalities—including positron emission tomography (PET), single-photon emission computed tomography (SPECT), computed tomography (CT), magnetic resonance imaging (MRI), and magnetic resonance spectroscopy (MRS)—offer critical diagnostic information. Among these techniques, MRI is regarded as the gold standard owing to its exceptional soft tissue contrast and broad clinical accessibility. Utilizing radiofrequency pulses in conjunction with a strong magnetic field, MRI enables high-resolution visualization of intracranial structures, making it particularly effective for detecting and characterizing brain abnormalities [8].

From a general perspective, T2-weighted (T2w) and FLAIR MRI sequences are essential for detecting brain lesions of various origins. In brain tumor assessment, these sequences help identify tumors and provide insight into their characteristics. T2w signal intensity reflects tissue density and cellularity, with highly cellular tumors often appearing hypointense. However, a hyperintense signal on T2w/FLAIR does not always indicate a tumor, as it may also represent peritumoral edema or infiltrative tumor tissue, particularly in gliomas [1].

Diffusion-weighted imaging (DWI) is an advanced MRI technique that quantifies the random thermal (Brownian) motion of water molecules within biological tissues. In isotropic diffusion, water molecules exhibit unrestricted movement in all directions, whereas anisotropic diffusion indicates directional restriction, often due to structural barriers such as cell membranes or fiber tracts. DWI allows for the derivation of the apparent diffusion coefficient (ADC), a quantitative parameter reflecting the degree of water diffusion. Since ADC values are closely associated with tissue cellularity and integrity, DWI offers critical insights into tumor microstructure in vivo. As a result, DWI has become an indispensable tool in oncologic neuroimaging, aiding in tumor detection, characterization, and treatment response assessment [3].

Materials and methods of research. This study was conducted at the Republican Specialized Scientific-Practical Center of Neurosurgery from January 2023 to September 2023. It included 30 patients (both male and female), aged between 20 and 80 years, who were suspected of having brain tumors and underwent MRI scans in the radiology department. Patients were selected through a convenient sampling method.

MRI scans can detect tumors in any lobe of the brain, allowing for an initial assessment of whether a tumor is benign or malignant. To enhance tumor visualization, Gadolinium contrast media is administered intravenously, with the dosage adjusted according to the patient's weight. For a definitive diagnosis and to differentiate between benign and malignant tumors, biopsy procedures may be performed.

Results and discussion. All collected data analyzed and tabulated in tables and graphs as follows:

Table 1

Frequency distribution of the patients by gender and age

Patients' distribution		Count	%
Gender	Female	16	53,3%
	Male	14	46,7%
Age	20 to 40 years old	11	36,7%
	40 to 60 years old	14	46,7%
	60 to 80 years old	5	16,7%

In table 1, showed that 53,3% of patients were females, with only 46,7% for males. However, some specific types of brain tumors, such as meningioma, are more common in women. Most patients had 40 to 60 years with 46.7%, then 36,7% for those who have 20 to 40 years old, and 16.7% from patients had 60 to 80 years old. Compared with other studies indicated that the number has been increased during the last past decayed and most of them are between age 50 to 70.

Table 2

Frequency distribution of the tumors by histological type

Nature of the tumor	Type of the tumor	Count	%
Benign	Meningioma	13	43,3%
	Pituatry adenoma	4	13,3%
Malignant	Anaplastic astrocytoma	8	26,6%
	Glioblastoma	3	10%
	Metastasis	2	6,6%

Table 2 displays the frequency distribution of brain tumors according to their histopathological classification, distinguishing between benign and malignant types. Among the benign tumors, **meningiomas** are the most common, accounting for **43.3% (n=13)** of cases, followed by **pituitary adenomas** at **13.3% (n=4)**. On the malignant side, **anaplastic astrocytomas** represent the highest proportion, comprising **26.6% (n=8)** of cases, while **glioblastomas** account for **10% (n=3)**. Additionally, **metastatic tumors** contribute to **6.6% (n=2)** of the total cases. This distribution highlights the predominance of benign tumors in the studied cohort, with meningiomas being the most frequently observed histological type.

Fig. no 1: A bar graph displays the frequency of malignancy type

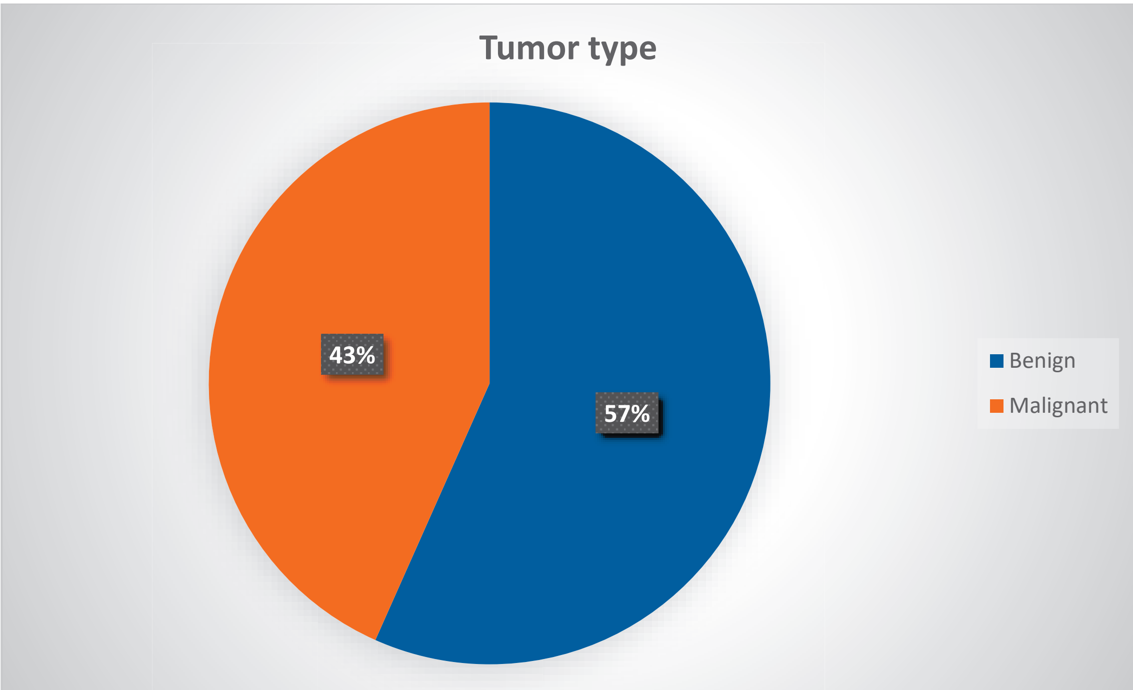
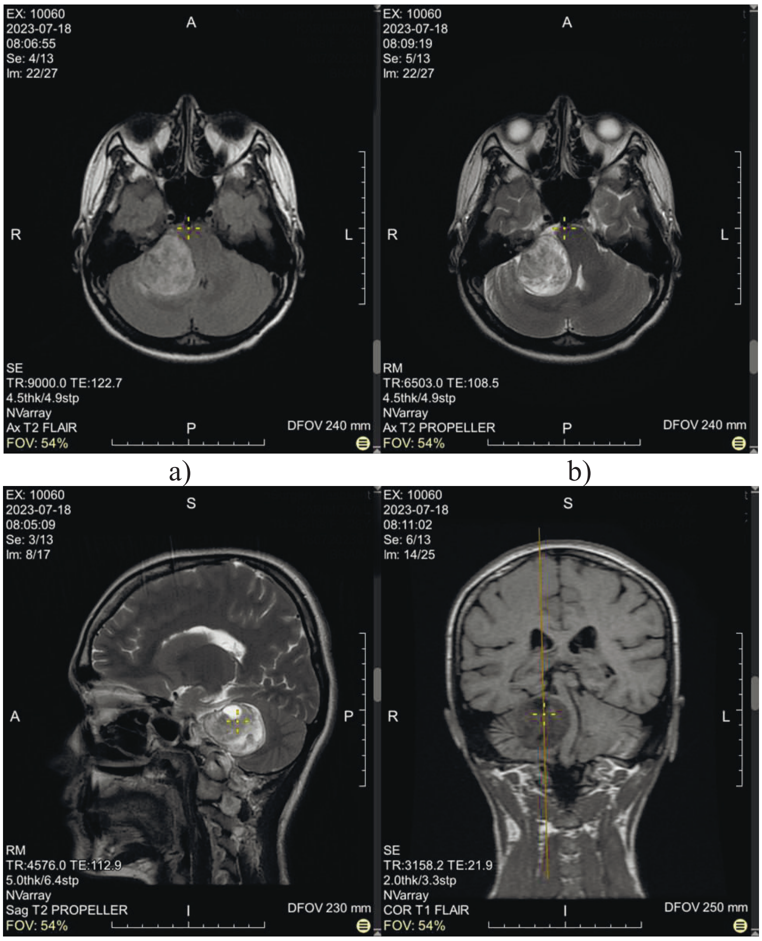


Fig. 1. Illustrates a bar graph depicting the frequency distribution of malignant tumor types. The graph visually emphasizes the variation in occurrence of tumors.



c) d)

Fig. 2. Illustrating MRI images of an extracerebral mass in the posterior cranial fossa meningioma in a 40-year-old patient:
a) T2-FLAIR image Axial; b) T2-weighted image Axial; c) T2-weighted image Saggital
d) T2-FLAIR image Coronal

In the projection of the right cerebellopontine angle, extending caudally to the level of the foramen magnum, an irregularly shaped mass is visualized, measuring 39.5 × 35 × 38 mm, with well-defined but uneven contours, a heterogeneous solid structure, mixed signal characteristics on T2 and FLAIR, hypointense on T1, causing compression of the brainstem and adjacent parts of the right cerebellar hemisphere.

Meningiomas are the most common **primary intracranial tumors**, arising from the **arachnoid mater**. MRI is the preferred imaging modality for their **detection, characterization, and differentiation** from other brain tumors.

Key MRI Features of Meningiomas:

T1-Weighted Imaging (T1WI): Typically, **isointense or slightly hypointense** compared to gray matter.

T2-Weighted Imaging (T2WI): Often **isointense to hyperintense**; may show cystic changes or peritumoral edema.

FLAIR (Fluid-Attenuated Inversion Recovery): Highlights peritumoral edema if present.

Contrast-Enhanced T1WI (with Gadolinium): **Strong, homogeneous enhancement** (hallmark feature). **Dural tail sign** – tapering enhancement along the dura, indicating meningeal involvement.

Diffusion-Weighted Imaging (DWI) & Apparent Diffusion Coefficient (ADC): **Low diffusion restriction**, distinguishing it from more aggressive tumors.

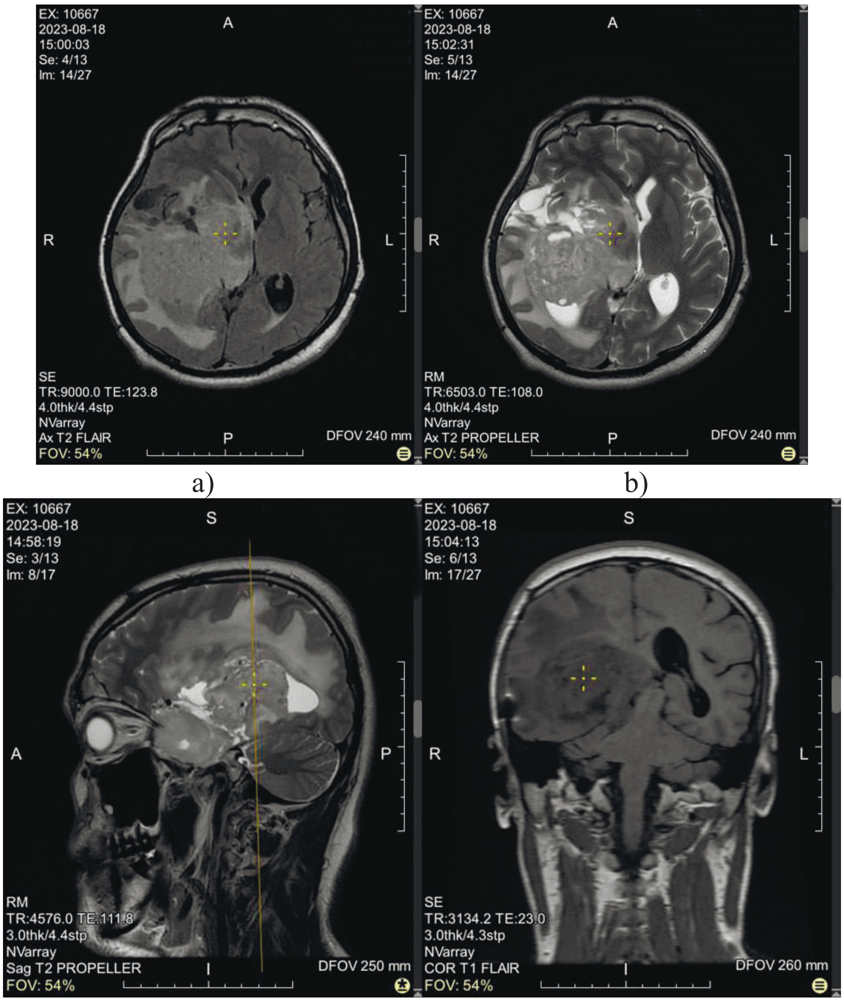


Fig. 3. Illustrating MRI images of a right temporal lobe anaplastic astrocytoma in a 56-year-old patient:
a) T2-FLAIR image Axial; b) T2-weighted image Axial; c) T2-weighted image Saggital
d) T2-FLAIR image Coronal

In the right frontoparietotemporal region, an irregularly shaped mass is visualized, measuring **87.1 × 84.3 × 77.6 mm**, with a heterogeneous cystic-solid structure. It extends into the **suprasellar and prepontine cisterns on the right**, as well as the **right cavernous sinus**, encasing the **M1 segment of the right internal carotid artery in a cuff-like manner**. The mass causes **compression of adjacent brain structures**. There is **marked peritumoral edema**.

Astrocytomas are a type of **glioma** arising from **astrocytes**, the star-shaped glial cells in the brain. MRI is the gold standard for diagnosing and classifying astrocytomas based on their **location, size, grade, and infiltration**.

Key MRI Features of Astrocytomas:

T1-Weighted Imaging (T1WI): **Low-grade astrocytomas** appear **hypointense or isointense** compared to gray matter.**High-grade astrocytomas (e.g., glioblastomas)** may have **necrotic** areas with heterogeneous signals.

T2-Weighted Imaging (T2WI) & FLAIR: Hyperintense lesions with poorly defined margins are commonly seen in low-grade astrocytomas. In higher-grade tumors, peritumoral edema is more prominent.

Contrast-Enhanced T1-Weighted Imaging (with Gadolinium): Low-grade astrocytomas typically exhibit minimal or no contrast enhancement. High-grade astrocytomas (Grade III–IV) often demonstrate irregular, ring-like enhancement due to necrosis and neovascularization.

Diffusion-Weighted Imaging (DWI) & Apparent Diffusion Coefficient (ADC): High-grade astrocytomas frequently show restricted diffusion, which is attributed to increased cellularity.

Conclusion. The primary aim of this study is to investigate the prevalence of brain tumors among both male and female populations and to evaluate the differential impact based on sex. Our analysis reveals a higher incidence of brain tumors in females compared to males. Furthermore, the age group most commonly affected falls between 40 and 60 years, a trend that aligns with our data. A key objective of this research is to assess the diagnostic value of Magnetic Resonance Imaging (MRI) in brain tumor evaluation. The results underscore the high diagnostic accuracy of MRI, highlighting its critical role in the detection, characterization, and comprehensive assessment of brain tumors.

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