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Comprehensive Analysis of Orbital and Ocular Tumors: Incidence, Imaging Characteristics, and Histopathological Correlation

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ABSTRACT

Background: Orbital and ocular tumors encompass a wide range of neoplasms that can lead to significant morbidity, particularly affecting vision and aesthetics. The study aimed to evaluate the diagnostic accuracy of magnetic resonance imaging (MRI) in characterizing these tumors and correlating imaging findings with histopathological diagnoses.

Methods: A total of 50 patients with a strong clinical suspicion of orbital tumors were included in this study. All participants underwent MRI using a 1.5 Tesla Magnetom Vision imager, following a standardized imaging protocol that included precontrast, T1-weighted, and T2-weighted sequences focused on the orbital region. The MRI findings were systematically analyzed and compared with histopathological results to determine diagnostic accuracy.

Results: MRI demonstrated a sensitivity of 92% and specificity of 88% in identifying orbital masses. Proptosis was observed in 70% of the patients, with variations in tumor types noted: 60% of the tumors were benign, while 40% were malignant. Lymphomas accounted for 25% of the malignant tumors, and rhabdomyosarcomas represented 15%. Most tumors were categorized based on size, with 30% classified as small (<2 cm), 50% as medium (2 to 4 cm), and 20% as significant (>4 cm). The imaging characteristics provided distinct features that facilitated differentiation between benign and malignant lesions, improving diagnostic accuracy.

Conclusion: MRI is an essential diagnostic tool for assessing orbital and ocular tumors, providing critical information that aids clinical decision-making. The study highlights the importance of early detection and a multidisciplinary approach to treatment, which can significantly enhance patient outcomes. Future research should explore advanced imaging techniques and genetic profiling to improve diagnostic accuracy and therapeutic strategies in managing these complex tumors.

Key-words: Histopathological diagnoses, Orbital and ocular tumors, Malignant tumors, Magnetic resonance imaging (MRI)

INTRODUCTION

Orbital and ocular tumors encompass diverse neoplasms that can arise in the eye or the orbit surrounding it. These tumors can be benign or malignant, congenital or acquired, with distinct characteristics in pediatric and adult populations. Orbital tumours present various clinical manifestations, such as proptosis and decreased vision, with a higher incidence of malignant tumours in adults compared to children [1].

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Common presenting symptoms of orbital tumors also include orbital pain and esthetically disfiguring changes [2]. These tumors can be classified into different categories based on their etiology, such as lymphoproliferative lesions, vasculogenic and cystic lesions, and metastases [3]. Malignant orbital tumors, including lymphomas, are on the rise globally, with increasing incidence rates observed in countries like the USA, the Netherlands, and South Korea [4]. Early detection of these tumors is crucial for prompt treatment initiation, often aided by neuroradiological imaging like magnetic resonance imaging (MRI) [5]. MRI has shown high diagnostic accuracy in identifying orbital masses, with excellent sensitivity and specificity in distinguishing between benign and malignant lesions, aiding in preoperative assessment and clinical

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management [6]. Additionally, studies have highlighted the importance of radiomics-based approaches using MRI data to differentiate between malignant and benign orbital lymphoproliferative disorders, enhancing the accuracy of diagnosis and guiding treatment decisions [7].

Pediatric orbital tumors, such as retinoblastomas and rhabdomyosarcomas, differ from those in adults and can lead to significant ophthalmologic consequences despite being predominantly benign [8]. Mesenchymal tumors, accounting for a notable percentage of orbital neoplasms, originate from various connective tissues within the orbit and surrounding areas, further adding to the complexity of orbital and ocular tumor management [9]. A study on orbital tumors found that proptosis is a frequent clinical characteristic, with differences in tumor types between childhood and adulthood, highlighting the challenge of managing these tumors in different age groups [1]. Overall, while childhood ocular tumors are mostly benign, they can still be life-threatening, underscoring the necessity for prompt diagnosis and appropriate referral for effective clinical management [10].

Orbital tumors can be managed through various treatment modalities depending on the type and extent of the tumor. In children, common orbital tumors like capillary hemangiomas can be treated with systemic non-selective β-blockers. At the same time, optic gliomas may require observation or interventions like chemotherapy, mTOR/MEK inhibitors, or radiation therapy [11]. Surgical approaches such as anterior transcutaneous or transconjunctival orbitotomy are utilized for dermoids and other masses, while cryoextraction is preferred for cavernous hemangiomas [12]. Radiotherapy plays a crucial role in treating both benign and malignant orbital tumors, providing excellent tumor control and preserving visual function, with indications for tumors like optic glioma, orbital rhabdomyosarcoma, and lacrimal gland tumors [13]. Malignant craniofacial tumors invading the orbit may require surgical resection, with outcomes showing that total resection improves survival rates, while orbital exenteration does not enhance survival and quality of life [14].

This investigation assessed fifty patients with possible orbital malignancies. It sought to create the best imaging technique possible for specific conditions and contrasted the accuracy of histological diagnosis with that of magnetic resonance imaging.

MATERIALS AND METHODS

This study included fifty individuals who were referred for orbital imaging. From December 2017 to September 2019, they had magnetic resonance imaging of the orbit performed in the Department of Radiodiagnosis at a 2,900-bed tertiary referral center.

Inclusion criteria- The study comprised patients who were sent for orbital imaging due to a strong clinical suspicion of orbital tumors and whose preliminary CT scans revealed an orbital area mass.

Exclusion criteria- Patients with general contraindications for MRI, such as those with cardiac pacemakers, cochlear implants, aneurysm clips, or any orthopedic implants deemed incompatible with MRI technology, as well as those who were claustrophobic, were not included in the study. Those patients who had previously undergone surgery for orbital tumors and were referred for a follow-up were excluded from the study.

Methodology- The MRI imaging was conducted using a 1.5 Tesla Magnetom Vision imager from Siemens, equipped with VB44 software and a standard head coil for optimal brain imaging. Before the scans, no specific patient preparation was necessary; however, in cases where patients exhibited uncooperative behavior, sedation was administered to facilitate the examination. All patients were instructed to remove metallic belongings to ensure safety during the MRI procedure. The imaging protocol commenced with a precontrast phase, beginning with a standard axial FLAIR brain screening sequence at a slice thickness of 5mm. Following this initial screening, high-resolution T1-weighted spin-echo (T1SE) and T2-weighted spin-echo (T2SE) sequences were performed, specifically focusing on the orbital region in all cases to enhance diagnostic accuracy.

Hemorrhage and calcification foci were assessed using the gradient sequence. In addition, Pd T2 axial sequences with a narrow field of view were acquired in conjunction with or instead of Pd T2 oblique sagittal sequences when doing so would improve anatomical delineation. The MRI

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interpretation of space-occupying lesions involved a The size of the lesion was categorized as small (largest diameter less than 2 cm), medium (between 2 to 4 cm), or large (more than 4 cm). Morphology and shape were evaluated for well-defined or ill-defined borders, with shapes including round, oval, fusiform, conical, dumbbell-shaped, or irregular configurations. Location was crucial and classified as intra-conal, extra-conal, both intra and extra-conal, intraocular, or with intracranial extension; additionally, the quadrant of the lesion was noted as superior, lateral, inferior, or medial. Signal intensity characteristics were compared to the extraocular muscles on T1-weighted (T1W), T2-weighted (T2W), Short Tau Inversion Recovery (STIR), and T1W fat-saturated sequences to determine if the lesion was isointense, hypointense, hyperintense, or heterogeneous. Finally, contrast enhancement was assessed for homogeneity versus inhomogeneity and graded as mild or intense. In addition, there were observations of mass effect, displacement, indentation on the globe, hemorrhage/calcification inside the tumor, involvement of extraocular muscles, flow holes or septae systematic assessment based on several key parameters. in the lesion, intracranial extension, and accompanying retinal detachment or optic atrophy. The hospital's pathology department's histological and MRI diagnoses were correlated.

Statistical analysis- The statistical analysis was performed using appropriate software to evaluate the data collected from the imaging studies. Descriptive statistics were utilized to summarize the demographic and clinical characteristics of the patients, including the distribution of age and sex. Comparative analyses were conducted to assess the differences in imaging characteristics among various types of orbital tumors.

Ethical approval- The study received ethical approval from the institutional review board, ensuring that all procedures adhered to ethical standards for research involving human subjects. Informed consent was obtained from all participants or their guardians before inclusion in the study.

RESULTS

In the present study, the youngest patient was a 4-month-old male child, while the eldest was a 75-year-old man. The maximum number of patients was in the 41- to 50-year-old age group (24%). The study on sex distribution in orbital tumors indicates a notable male predominance among the cases studied, with 60% of the patients being male (30 cases) compared to 40% female (20 cases).

The findings of the distribution of various pathologies indicate that the largest segment, constituting 22% of the total, was attributed to lymphomas. The second largest category was pseudotumors, which made up 20%. Hemangiomas contributed to 16% of the pathologies, while meningolomas and retinoblastomas each account for 8%. Furthermore, optic nerve gliomas and dermoid pathologies represent 6% of the distribution. Smaller categories include melanoma and lymphangioma, each at 2%, and hemangiopericytoma, schwannoma, metastasis, and pleomorphic adenoma, each comprising 2%. The 'others' category also represents 2% of the distribution (Fig. 1). These percentages elucidate the prevalence of different pathologies within the dataset presented.

The sensitivity and specificity of diagnostic tests for the five most common pathologies showed that the sensitivity of pseudotumor detection is 70%, which means that 70% of confirmed cases are identified correctly. In contrast, its specificity is 52.5%, indicating a comparatively lower ability to identify those without the pseudotumor correctly. Conversely, the optic nerve sheath meningioma shows 100% sensitivity and specificity, accurately identifying both true positives and true negatives. Cavernous hemangioma also stands out with a high sensitivity of 87.5% and perfect specificity at 100%, demonstrating strong performance in identifying and excluding the disease. Lesser sensitivity is observed in lymphomas at 72.7%, although its specificity at 92.31% is still relatively high. Retinoblastoma demonstrates a sensitivity of 75% with perfect specificity of 100% (Table 1). The variance in these values across different pathologies highlights each condition's challenges and diagnostic accuracies.

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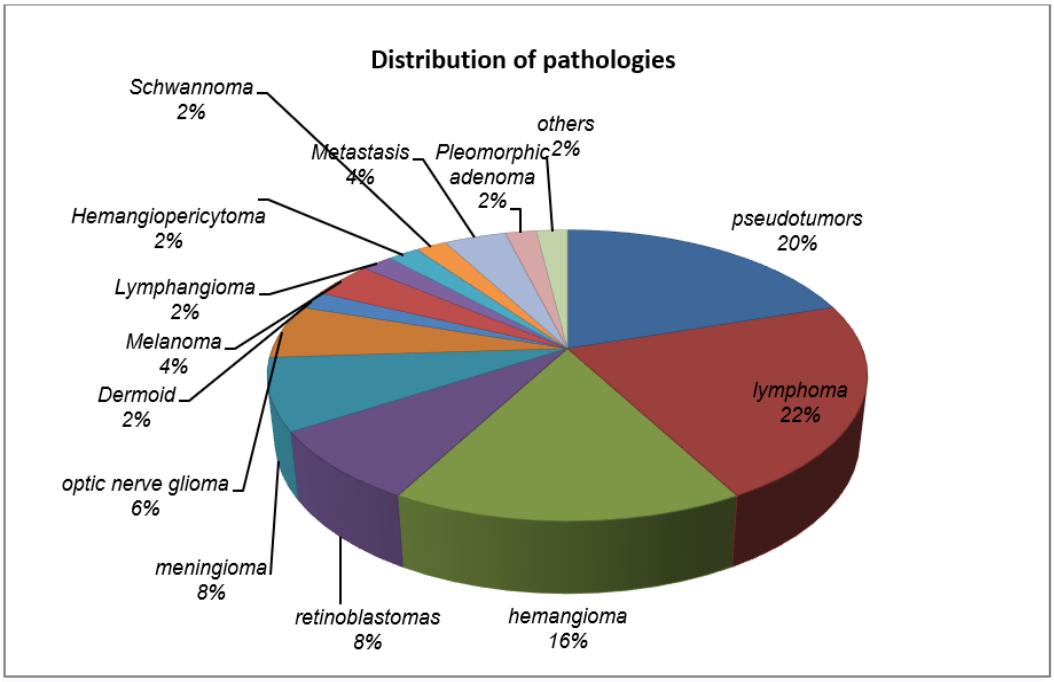

Fig. 1: Distribution of orbital tumors

Table 1: Sensitivity and specificity for the most typical 5 pathologies.

Tumor	Sensitivity (%)	Specificity (%)
Pseudotumor	70	92.5
Lymphoma	72.7	92.31
Cavernous hemangioma	87.5	100
Retinoblastoma	75	100
Optic nerve sheath meningioma	100	100

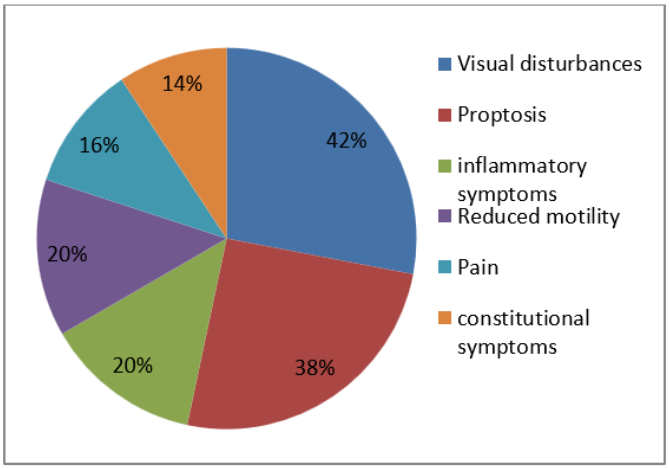

Fig. 2: Common clinical symptoms in orbital tumors.

The data on various symptoms experienced by patients with orbital tumors showed that the most common symptom reported is visual disturbances, which occurred in 21 cases, comprising 42% of the total. Proptosis is the next most frequent symptom in 19 cases (38%). Inflammatory symptoms were observed in 10 cases, making up 20% of the total. Both reduced extraocular motility and pain were present in 10 cases (20%) and 8 cases (16%), respectively. Finally, constitutional symptoms were reported in 7 cases, accounting for 14% (Fig. 2). This data provides a clear overview of the prevalence of different symptoms in patients with orbital tumors, which can help better understand and diagnose this condition.

The location of lesions in orbital tumors indicated that most cases were found in the extra conal region, accounting for 36% of the total cases, suggesting a prevalence of lesions located outside the muscle cone of the orbit. The "Both" category, which included intra and extra-conal lesions, represented 28% of the cases, indicating a significant occurrence of mixed lesions. Intraconal lesions constituted 22% of the cases, while intraocular lesions were the least common, comprising only 14%. This distribution highlighted the varied anatomical locations of orbital tumors, with a notable tendency for lesions to be extra conal, which may have had implications for diagnosis and treatment strategies.

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Fig. 3 represents the distribution of pediatric orbital tumors by type, number of cases, and the corresponding percentage of total cases. Retinoblastoma has the highest occurrence, with 4 cases representing 44.4%. Optic nerve Glioma follows with 3 cases, making up 33.3%. Both Pseudotumor and Hemangioma have 1 case each, corresponding to 11.1% of the total cases for each type.

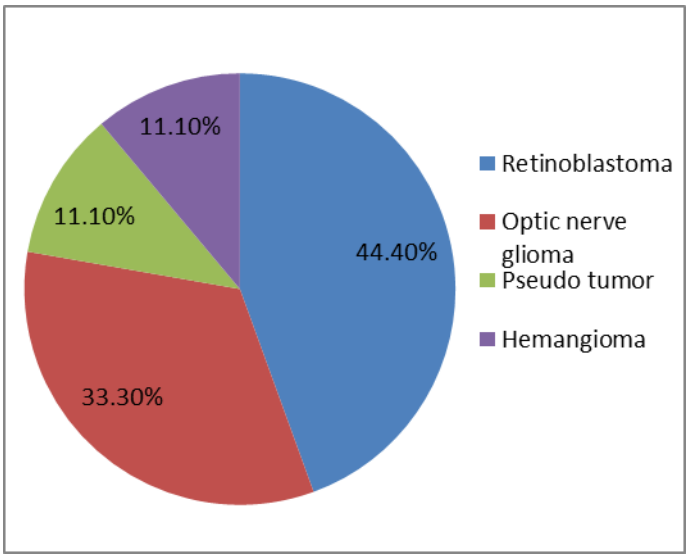

Fig. 3: Distribution of pediatric orbital tumors.

The findings from Fig. 4 indicate that both pseudotumors and lymphomas predominantly affect older adults, particularly in the 5th and 6th decades of life. The absence of cases in younger age groups, especially in the 1st decade, underscores the rarity of these conditions in children and adolescents. The data suggest a clear age-related trend, with a significant increase in the incidence of these orbital tumors as patients age.

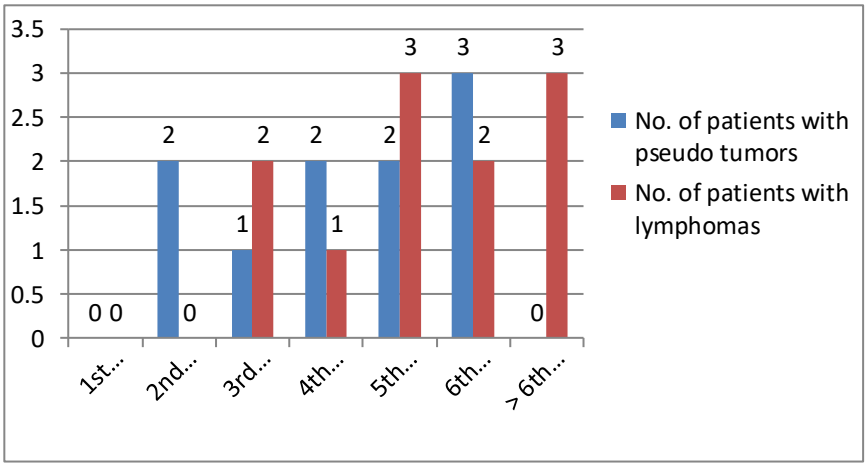

Fig. 4: Age distribution in Pseudo tumor and Lymphoma patients

The findings from Table 2 indicate that inflammatory symptoms are present in a significant proportion of patients with pseudotumors, with 60% sensitivity suggesting that these symptoms can identify some cases but also highlighting that a considerable number may be missed. Additionally, the presence of inflammatory symptoms in 4 cases of other diagnoses emphasizes that such symptoms are not exclusive to pseudotumors. The high specificity of 90% indicates that the absence of inflammatory symptoms is a strong indicator against the presence of pseudotumors, making it a valid diagnostic criterion. Overall, while inflammatory symptoms can aid in diagnosing pseudotumors, clinicians should be cautious and consider further evaluation to ensure accurate diagnosis.

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Table 2: Incidence of inflammatory symptoms in pseudotumors.

Inflammatory symptoms	Pseudo tumors	Other diagnoses	Sensitivity	Specificity
Yes	6	4	60%	90%
No	4	36		

In a comparative analysis of T2 weighted signal intensity (T2W SI) between pseudotumors and lymphomas, the results indicate that among the 10 pseudotumor cases, 8 (80%) exhibited isointensity relative to muscle, while 2 (20%) were hyperintense; similarly, when compared to fat, 8 (80%) were isointense and 2 (20%) hyperintense. In contrast, for the 11 lymphoma cases evaluated, 10 (90.9%) showed isointense compared to muscle, and only 1 (9.1%) was hyperintense; regarding fat comparison, 2 (18.1%) were isointense, while a significant majority of 9 (81.9%) displayed hyperintensity (Table 3 & Fig. 5).

Table 3: T2 weighted signal intensity of pseudotumor and lymphoma.

Tumor	T2W SI compared to muscles		T2W SI compared to fat	
	Isointense	Hyperintense	Isointense	Hyperintense
Pseudotumor (n=10)	8 (80%)	2 (20%)	8 (80%)	2 (20%)
Lymphoma (n=11)	10 (90.9%)	1 (9.1%)	2 (18.1%)	9 (81.9%)

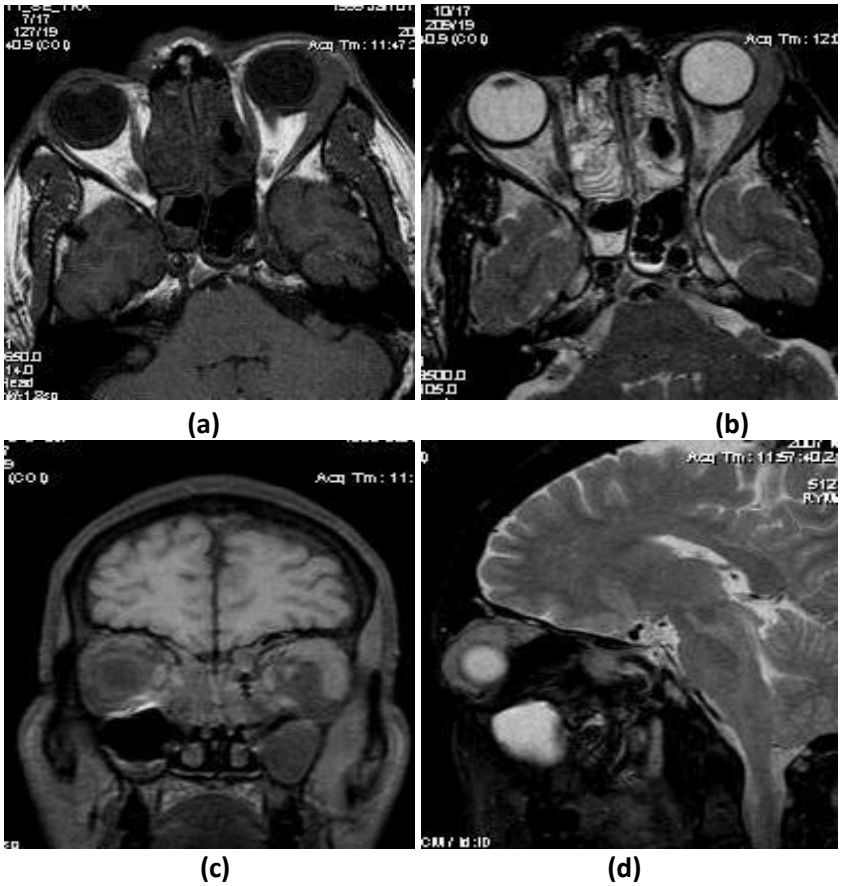

Fig. 5: A 52-year-old man with pseudo tumor (a) T1W axial and (b) A PdT2W axial images showing an iso intense lesion in the left superolateral aspect involving lateral rectus and the lacrimal fossa. (c) T1W Coronal image showing isointense mass also seen to be involving superior rectus muscle. (d) T2W Sagittal image showing a hypointense lesion in the superior aspect of orbit.

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In a comparative analysis of signal intensity between T1-weighted imaging (T1WI) and T2-weighted imaging (T2WI) for lesions identified as pseudotumors and lymphomas, the data reveals that for pseudotumors, there are 2 instances where T1WI signal intensity is greater than T2WI, contrasted with 9 instances where T1WI signal intensity is less than T2WI. In the case of lymphoma, there is 1 instance where T1WI exceeds T2WI; similarly, there are 9 instances where T1WI is inferior to T2WI. This indicates a predominant trend across both lesion types towards lower signal intensity on T1WI compared to T2WI (Table 4).

Table 4: Comparison of T1W and T2W signal intensity in lymphoma and pseudotumor.

Signal intensity / **Lesion**	**T1WI > T2WI**	**T1WI < T2WI**
Pseudotumor	2	9
Lymphoma	1	9

DISCUSSION

The current study aimed to assess MRI findings in orbital malignancies and the diagnostic accuracy of MRI in their characterization and diagnosis. This was accomplished by linking MRI findings to histological diagnoses. The patients in the study belonged to a wide age range, spanning from 4 months to 75 years. However, most patients (approximately 40%) fell within the fifth and sixth decade of life. In terms of sex distribution, the study revealed a male preponderance, with a sex ratio of 1:1.5. In contrast to the present study, a retrospective study conducted by Ohtsuka *et al.* [15] on 244 orbital tumors reported a mean age of patients to be 48.7 years. They, however, found a female preponderance of 0.8:1. This disparity in sex ratio could be attributed to differences in sample size or epidemiological factors.

In our study involving 9 pediatric patients with orbital tumors, the distribution of diagnoses revealed that retinoblastoma was the most prevalent, affecting four patients (44.4%). Following this, three patients (33.3%) were diagnosed with optic nerve glioma, while one patient each was identified with a hemangioma and a pseudo tumor, both accounting for 11.1% of the cases. This data indicates that benign lesions were more common than malignant ones, comprising 55.6% of the total cases compared to 44.4% for malignant tumors. Supporting these findings, Johnson *et al.* [16] conducted a study on 141 children with orbital tumors and reported similar results; they found retinoblastoma to be the most common tumor in children at 32%, followed by vasculogenic tumors at 22%.

In the present study involving 10 patients diagnosed with pseudotumors, the demographic distribution revealed that 7 (70%) were male, while 3 (30%) were female. Notably, only 1 patient (10%) fell within the pediatric age group, indicating that most cases occurred in adults, particularly between the third and sixth decades of life, accounting for 70% of the total cases. Furthermore, all instances of pseudotumors were unilateral. These findings align closely with those reported in studies conducted by Yan *et al.* [17], reinforcing the observed trends in patient demographics and characteristics.

Clinical symptoms were categorized into two groups: those resulting from mass effect and those indicative of inflammation. The symptoms associated with the mass effect included proptosis, blurring of vision, and restriction of extraocular movements. In contrast, the inflammatory symptoms encompass pain, chemosis, and eye watering. Notably, 6 out of the 10 patients (60%) exhibited signs of inflammation and proptosis, while the remaining 4 patients (40%) presented solely with symptoms related to mass effect without any evidence of inflammation. This observation aligns with findings from studies conducted by Yan *et al.* [17] and Gunalp *et al.* [18], which reported that proptosis and motility restriction were prevalent symptoms in most cases.

On T1W imaging, all tumors appeared isointense with muscles, indicating nonspecific signal intensities. Simultaneously, on T2W imaging, nine (81.1%) were hyperintense to fat and ten out of eleven (90%) were isointense to muscle. Two tumors (18.1%) showed a reduction in intensity on T2W compared to T1W imaging; the remaining cancers showed an iso-hyper contrast between T2W and T1W imaging. The results of Yan *et al.* [17] and Cytryn *et al.* [19] are comparable to these findings. On contrast-saturated T1W images, every lesion showed

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enhancement, with 6 out of 11 tumors (54.5%) exhibiting severe enhancement. Eight (72.7%) of the lymphoproliferative lesions were malignant and three (27.3%) benign upon histological characterization. Three (27.3%) of the eight were reactive lymphoid proliferation, five (45.5%) were B cell lymphomas, one (0.9%) was a T cell lymphoma, and two (18.1%) were plasmacytomas in individuals who tested positive for cancer. The distribution aligns with what was observed in Yan *et al.'s* study [17]. Of the 11 individuals, 4 had skeletal alterations and 4 had intracranial expansion (i.e. 36.3%).

CONCLUSIONS

The study paper emphasizes the critical role of MRI in diagnosing and characterizing orbital and ocular tumors. MRI findings correlate well with histopathological diagnoses, accurately identifying various tumor types. The study underscores the importance of recognizing clinical symptoms, categorized into mass effect and inflammatory signs, to guide diagnosis and treatment. Additionally, the demographic trends observed, including age distribution and sex prevalence, provide valuable insights for clinicians in managing these conditions. The findings advocate for a multidisciplinary approach to assessing and treating orbital tumors, ensuring timely and effective patient care. The study's prospects include integrating advanced imaging techniques and machine learning to enhance diagnostic accuracy and exploring genetic profiling to identify biomarkers for targeted therapies in orbital tumors.

Additionally, fostering multidisciplinary collaboration will improve comprehensive management strategies and patient outcomes.

CONTRIBUTION OF AUTHORS

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Research design- Vaibhav Sabnis
Supervision- Deoyani Sarjare
Materials- Vaibhav Sabnis
Data collection- Vaibhav Sabnis
Data analysis and interpretation- Tejas Sadavarte
Literature search- Tejas Sadavarte
Writing article- Vaibhav Sabnis
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Article editing- Deoyani Sarjare, Vaibhav Sabnis
Final approval - Deoyani Sarjare, Vaibhav Sabnis, Tejas Sadavarte

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