Evaluation of Meningioma of the brain and spine with Computerized Tomography and Magnetic Resonance Imaging

Sultan Alshoabi1,2, Moawia Gameraddin1,3, Suliman Salih1, Jumaa Tamboul1, Fathelrehman Alagab1, Suzan Abdelmaboud3

1 Department of Diagnostic Radiologic Technology, Taibah University, Faculty of Applied Medical Sciences, Saudi Arabia
2 Department of Radiology, Al-Thawra Modern General Hospital, Sana'a, Republic of Yemen.
3 Faculty of Radiological Sciences and Medical Imaging, Alzaiem Alazhari University, Sudan.

Corresponding Author: Moawia Bushra M. Gameraddin. Taibah University, Almadinah Almunawarah. P.O. Box 30001 E-mail: m.bushra@yahoo.com Tel: 00966534821130

Abstract

Objectives: The aim of this study is to study the site, size, types and radiographic features of meningioma in the brain and the spine of human body by using CT-scan and MRI imaging modalities.

Methods: Fifty cases of meningioma of the brain and spine was collected by using 64 multi-slice CT-scanner using the protocol of imaging of the head and 1.5 tesla MRI using the protocol of imaging of the head and spine.

Results: Most cases of meningiomas were in the brain and few were in the spine. Most cases were in females between the ages of 18 and 75 years old. The male to female ratio was 82:18. The ratio of calcification was 18%. The most common type of brain meningioma was convexity meningioma. Neurological deficits were the most common presenting symptoms.

Conclusion: Meningioma is most common in females than in males and more common after 40 years old age and usually they are convexity meningioma in the brain. MRI scanning is currently the best diagnostic modality for detecting the brain and spine meningiomas it provides excellent detail regarding to the site, size, shape, intensity and enhancement after contrast administration.

1. Introduction

Meningioma is a primary central nervous system tumor arises from the meningeal membrane that surrounds the brain and the spinal cord [1]. Meningioma is the most common extra-axial central nervous system tumor and
often discovered in the middle to late adult life especially in women [2]. They are a non-glial neoplasm that originates from the arachnoid cap cells of the meninges that surrounds the brain and the spinal cord. Progressive enlargement of the tumor leads to focal or generalized seizure disorders or neurological deficits caused by compression of adjacent neural tissue [3]. Meningioma’s have characteristic imaging findings although there are many variants. Most meningioma’s (90%) are benign and the remaining 10% being atypical or malignant tumors. Meningiomas are most common between the ages of 40 to 70 years but can occur at any age including childhood and are more common in women with a female: male ratio of almost 3 to 1 in the brain and up to 6 to 1 in the spinal cord [1]. Usually meningioma is solitary at one site, but meningioma have possible to be several tumors growing simultaneously in different parts of the brain and spinal cord in neurofibromatosis type-2(1). The causes of meningioma are not well understood [3]. Most cases are sporadic, appearing randomly, while some are familial. Persons who have undergone radiation, especially to the scalp, are more at risk for developing meningioma, as are those who have suffered from brain injury at some time [4].

Meningiomas are more likely to appear in women than men, though when they appear in men, they are more likely to be malignant. Meningiomas are becoming more likely with old age. They have been observed in all cultures, Western and Eastern, in roughly the same statistical frequency as other possible brain tumors [5, 6].

Many individuals have meningioma, but remain asymptomatic, so the meningioma are discovered during an autopsy. One to two percent of all autopsies reveal Meningiomas that were unknown to the individuals during their lifetime, since there were never any symptoms. In the 1970s, tumors causing symptoms were discovered in 2 out of 100,000 people, while tumors discovered without causing symptoms occurred in 5.7 out of 100,000, for a total incidence of 7.7/100,000. With the advent of modern sophisticated imaging systems such as CT-scan the discovery of asymptomatic meningioma has tripled [6]. Meningioma are classified according to the site into the following types:-

1- Convexity meningioma: describes those tumors whose attachment does not occur on the dura of the skull base or does not involve the dural venous sinus or falx cerebri. The tumor may arise from any area of the dura over the convexity [7].

2- Parasagittal meningiomas: account for the 17–20% morbidity rate of intracranial meningiomas and the 33% morbidity rate of parasagittal and falx meningiomas [8].

3- Olfactory groove meningiomas (OGMs): arise over the cribriform plate and may reach very large sizes prior to presentation. They can be differentiated from tuberculum sella Meningiomas because OGMs arise more anterior in the skull base and displace the optic nerve and chiasm inferiorly rather than superiorly [9].

4- Optic nerve sheath meningiomas (ONSMs): grow slowly and, if untreated, patients may have stable visual function for up to several years. Treatment of an ONSM may lead to vision loss (radiation retinopathy or optic neuropathy) [10].
5- Sphenoid wing *en plaque* Meningiomas:- are a subgroup of meningiomas defined by its particular sheet-like dural involvement and its disproportionately large bone hyperostosis. *En plaque* Meningiomas represent 2-9% of all meningiomas and they are mainly located in the sphenoid wing. Total surgical resection is difficult and therefore these tumors have high recurrence rates [11].

6- Tentorial meningiomas account for 2–6% of all intracranial meningiomas¹. Tentorial meningiomas can arise from the lateral and posterior portion of the tentorium near or adjacent to the major venous sinuses or from the medial portion (i.e., tentorial incisura) near or adjacent to critical neurovascular structures[12].

7- Intra-ventricular meningiomas:- is a rare but well-described tumor, most often located in the trigone of the lateral ventricles. It constitutes approximately 0.5% to 2% of all intracranial meningiomas. The majority present in the fourth to the sixth decades of life and show a predominance in women of approximately 2:1. Neurofibromatosis should be suspected when such a tumor is found in children. The appearance on imaging studies is similar to that of other meningiomas, being sharply defined and globular. On CT scans, these tumors are usually hyperdense and may contain foci of calcification. Meningiomas are iso- or hypointense on T1-weighted MR images, and iso- or hyperintense on T2-weighted images [13].

8- Spinal meningiomas: Meningiomas account in our experience of 46% of the spinal cord tumors and account the 7.5% of all meningiomas. They are more frequent in females most frequently occur in the thoracic region and have low recurrence rate. Typically, they are located in the intradural extramedullary space, grow slowly, and spread laterally in the subarachnoid space. MRI is the best imaging technique for diagnosis of spinal tumors and total tumor resection improved the surgical results of spinal meningiomas[14].

A meningioma may be detected on an imaging test, such as:

1- Computerized tomography (CT) scan uses X-rays that create cross-sectional images (like slices) of the brain and head.

2- Magnetic resonance imaging (MRI). With this imaging study, a magnetic field and radio waves are used to create cross-sectional images of the structures within the brain. MRI scan provide more detailed images of the brain and meningiomas (16)Magnetic resonance imaging (MRI) of the head provides superior soft tissue discrimination as compared to CT scans when seeking information about headache to confirm a diagnosis of neoplasm, vascular disease, posterior cranial fossa lesions, cervicomedullary lesions, or intracranial pressure disorders. It also does not carry the risks of exposing the patient to ionizing radiation.

1.1 Treatment

Surgery may pose risks including infection and bleeding. The specific risks of surgery will depend on where the meningioma is located. For instance, surgery to remove a meningioma that occurs around the optic nerve can lead to vision loss. Although meningiomas are benign, petroclival meningiomas remain a clinical challenge because of their critical location adjacent to brain, cranial nerve, and vascular structures, Gamma Knife surgery
was used as either primary or adjuvant treatment of 168 petroclival meningiomas involving the region between the petrous apex and the upper two-thirds of the clivus. The most common presenting symptoms were trigeminal nerve dysfunction, balance problems, diplopia, and hearing loss [15].

Radiation therapy:- If the meningioma can't be completely removed, the doctor may recommend radiation therapy following surgery. The goal of radiation therapy is to destroy any remaining meningioma cells and reduce the chance that meningioma may recur. Advances in radiation therapy increase the dose of radiation to the meningioma while reducing radiation to healthy tissue. These include fractionated stereotactic radiotherapy (SRT) and intensity-modulated radiation therapy (IMRT). Proton beam radiation may be an option, but whether this is superior to standard radiation is unclear [16].

Radiosurgery:- Radiosurgery is a type of radiation treatment that aims several beams of powerful radiation at a precise point. Contrary to its name, radiosurgery doesn't involve scalpels or incisions. Radiosurgery typically is done in an outpatient setting in a few hours. Radiosurgery may be an option for people with meningiomas that can't be removed with conventional surgery or for meningiomas that recur despite treatment [17].

2. Materials and Methods

2.1. Study population:

This is a retrospective study conducted in Al-Thawra Modern General Hospital Sana'a during the period of 2009 and 2012. There were 50 cases of meningioma of the brain and spine had been retrospectively selected to satisfy the study.

2.2. Imaging procedures

The patients were imaged with either one or two imaging modalities, CT scan and MRI.

There were 18 patients had been scanned with 64 multi-sliced CT scanner (computerized tomography) using the protocol imaging of the head. The patient is supine with the head centered at the gantry and fixed in position. Exposure factors were selected with slice thickness 10mm and low osmolar water soluble contrast media was injected intravenously. The image interpretation was performed with consultant Radiologists to confirm the diagnosis.

The remaining patients (32) were imaged with Magnetic resonance imaging (MRI) 1.5 tesla. The patients were scanned in supine position using the protocol of heads or spine. The MRI imaging parameters which were selected include; slice thickness is 10mm, T1 weighted images, T2-weighted images and T1-weighted images with contrast injection. The contrast medium which was used is intravenous Gadolinium; the amount is dependent on weight of the individual (0.1ml per Kg). The diagnosis was performed by MRI consultant Radiologists.
2.3. Statistical Analysis: The data was analyzed using SPSS software programme. Most of the study variables were qualitative and descriptive, so we used percent's to describe and analyze the data.

3. Results

This study was performed in 50 patients, 41 were females while 9 were males and their ages ranged between 18 to 75 years old. They had been referred for CT-scan examination of the brain or MRI examination of the brain or spine. Meningiomas were higher in females (41 cases) than males (9 cases). Most cases were Meningiomas in the brain (45 cases) and few were in the spine (5 cases) and most of the meningiomas in the spine were in the thoracic spine (3 cases). The ratio of calcification in meningiomas was 18%. More than half of meningiomas in this study showed edema around them (60%) and in most of them edema was slight and not significant. The most common type of brain meningioma was convexity meningioma (11 cases) then cerebellopontine angle meningioma (8 cases), parasellar meningioma (7 cases), parasagittal meningioma (4 cases), Olfactory meningioma (3 cases), meningioma en plaque (3 cases), multiple meningiomas in neurofibromatosis type-2 (3 cases), subfrontal meningioma (2 cases), tentorial meningioma (1 case), skull base meningioma (1 case), foramen magnum meningioma (1 case) and optic nerve meningioma (one case). Most meningiomas in this study appear hyperdense on NCCT and showed strong enhancement after contrast administration and also on MRI most cases showed moderate signal intensity on both T1 and T2 weighted images with strong homogenous enhancement after Gadolinium administration.

![Figure 1. The present calcification in meningioma.](image-url)
Table 1. The different types of meningioma

<table>
<thead>
<tr>
<th>Type of Meningioma</th>
<th>No. of cases</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Convexity meningioma</td>
<td>11</td>
<td>22%</td>
</tr>
<tr>
<td>2- CPA meningioma</td>
<td>8</td>
<td>16%</td>
</tr>
<tr>
<td>3- Spinal cord meningioma</td>
<td>5</td>
<td>10%</td>
</tr>
<tr>
<td>4- Parasellar meningioma</td>
<td>7</td>
<td>14%</td>
</tr>
<tr>
<td>5- Parasagittal meningioma</td>
<td>4</td>
<td>8%</td>
</tr>
<tr>
<td>6- Multiple meningiomas(NF-2)</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>7- Olfactory meningioma</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>8- En plaque meningioma</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>9- Subfrontal meningioma</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>10- Optic nerve meningioma</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>11- Tentorial meningioma</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>12- Skull base meningioma</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>13- Foramen magnum</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>50 case</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Figure 2. Distribution of gender in study population.
Figure 3. Right CPA Meningioma on T1 weighted images and shows strong homogenous enhancement after Gadolinium administration.

Figure 4. Meningioma en plaque in right sphenoid bone with extension into the surrounding tissue.
4. Discussion

This study was performed in 50 patients, 41 were females while 9 were males and their ages were ranged from 18 to 75 years old. They had been referred for brain CT scanning and MRI examination for the brain or the spine.

This study shows that meningiomas are more common in women than in men with a female: male ratio of 80:20 and the cases were ranged from 18 to 75 years old. These findings were similar to the findings of Olivero WC et al., (1995) who reported that the female: male ratio was 75:25 whose ages ranged from 38 to 84 years, with a mean age of 66 years(18). The study showed that the most common type of meningioma was convexity meningioma. This result was consistent with Olivero WC et al. (1995) who reported that the most common tumor location was convexity [18].

The appearance of meningioma on CT-scan was hyperdense in most cases. This was agreeing with a study conducted by Omar Islam(Aug 2014) who found that approximately 70-75% of meningioma's are hyper attenuating to surrounding brain parenchyma, while roughly 25% are isodense and The administration of intravenous contrast in evaluating meningiomas is helpful, as more than 90% of cases will demonstrate intense homogeneous enhancement[19].

The study showed that 18% of meningioma cases had calcification that result was consistent with Omar Islam (2014) who wrote that calcification is another common finding, seen in approximately 20-25% of cases. The CT nature of the calcification may be nodular, fine and punctate, or dense. Surrounding parenchymal vasogenic edema is common, identified as hypo dense brain tissue. Occasionally, the edema is extensive and, as it predominantly affects white matter, can resemble fingers of low attenuation. Edema, however, is absent in approximately 50% of cases because of the neoplasm's slow growth [19].

This study shows that meningiomas predominantly were of intermediate to low signal intensity on T1 and T2 weighted images but some were high signal intensity on T2 weighted images and almost all meningiomas in this study showed strong enhancement after Gadolinium administration. We can compare this results with a study conducted by Elster AD, Challa VR, Gilbert TH et-al who found that the magnetic resonance (MR) appearances of 40 biopsy-proved meningiomas were blindly evaluated and correlated with their predominant histologic pattern--fibroblastic, transitional, syncytial, angioblastic, or mixed. T1-weighted images were not particularly useful in discriminating pathologic subtype, because most tumors were isointense with or hypointense to cortex regardless of histologic type. Signal intensity and features on T2-weighted images strongly correlated with histopathologic findings in over 75% of cases, however. Meningiomas markedly hypointense to cortex on T2-weighted images (seven of 40 cases) were composed predominantly of fibroblastic or transitional elements, while markedly hyperintense meningioma's (14 of 40 cases) demonstrated predominance of syncytial or angioblastic elements. Consideration of secondary features visible at MR imaging (degree of edema, cyst formation, presence of calcium aggregates) led to a more specific histologic prediction in over half of the remaining isointense tumors. The varied MR appearance of meningiomas has a clear histologic basis, and crude prediction of pathologic subtype is possible in over three-fourths of cases [20].
5. Conclusion

MRI is the image modality of choice to evaluate meningioma as it provides excellent detail regarding to the site, size, shape, density and enhancement after contrast administration and MRI scanning is currently the best diagnostic modality for detecting the brain and spine meningioma. Meningioma is most common in female than in males and more common after 40 years old age. Predominantly meningioma appears hyperdense on NCCT (Non-contrast CT) with strong homogenous enhancement after contrast administration and most meningioma have minimal edema around them. Meningiomas shows calcification in 18% of cases and shows edema in 60% of cases and the edema was minimal and not significant in most cases.

On MRI, meningioma usually appears of moderate SI on both T1WIs and T2WIs but sometimes may appear low SI on T1 weighted images and high SI on T2WIs and all meningioma shows strong enhancement after Gadolinium administration.

The most common brain meningioma’s are convexity meningioma then parasagittal and cerebellopontine angle meningioma.

Competing Interests
No competing interest exists.

Ethical Approval
Not needed.

References


[6]. Park, Bong Jin; Kim, Han Kyu; Sade, Burak; Lee, Joung H. Epidemiology, Meningiomas. 2009: 11–13. doi.org/10.1007/978-1-84628-784-8_2


[9]. Stephen J. Hentschel, MD, FRCS(C), Franco Demonte, MD, FRCS(C).Olfactory Groove Meningiomas.Neurosurg Focus. 2003;14(6)


[19]. Omar Islam, MD, FRCP(C); Chief Editor: James G Smirniotopoulos Imaging in Brain Meningioma: Updated: Aug 27, 2014.