The role of multidetector computed tomography and magnetic resonance recent imaging techniques in the evaluation of intra-conal orbital lesions

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MDCT;
Recent MRI techniques;
Intra-conal masses

Abstract  Objective: The purpose of our study was to assess the role of multi-detector computed tomography and magnetic resonance recent imaging techniques in the evaluation of intra-conal orbital lesions.

Subjects and methods: 30 patients presented to the Ophthalmic and Radiology Departments at El-Minia University Hospital and El Minia Oncology Center with clinical diagnosis of visual loss and proptosis. They presented during the period from June 2012 to October 2013. Their ages range from 5 to 73 years. All patients subjected to MDCT and MRI. Also, contrast injection was injected on some cases. 24 patients were subjected to surgery and histopathology to confirm the radiological diagnosis.

Results: A total of 30 patients were included (their mean age 26 years). 8 lesions were diagnosed inflammatory in nature (4 were orbital abscess and 4 were idiopathic orbital inflammatory disease i.e. pseudo tumors). 10 lesions were diagnosed as vascular lesions (2 lesions were carotid cavernous fistula and 8 lesions were cavernous hemangiomas). 6 lesions were diagnosed as optic nerve gliomas and other 6 lesions were diagnosed optic nerve sheath meningiomas.

Conclusion: The use of MDCT and MRI recent techniques are mandatory for accurate diagnosis of the nature of intra-conal orbital mass lesions.

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1. Introduction

Orbital lesions represent a difficult radiological problem, requiring specific techniques for their demonstration. The radiologist is called upon to define the limits, extent and nature of the lesion. Multi-detector computed tomography (MDCT) and...
Magnetic resonance (MR) imaging recent techniques, both offer excellent resolution of orbital tissues and lesions (1).

The current CT scanners have better spatial resolution with lower noise, shorter scanning times with reduced radiation exposure, better reconstruction algorithms and the capability of generating thinner sections. It is superior to other imaging modalities for the bony orbit with adequate differentiation of soft tissues (4). CT is the modality of choice in evaluating lesions that invade the orbital bony walls primary or secondary as well as, bony changes associated with some intra-orbital lesions (2).

MR imaging is particularly useful in imaging structures that are problematic to image by other techniques. MRI technology has also, improved, allowing for better resolution from the use of surface and head coils. Its multi-planar capability (that alleviates the need for the patient to be repositioned) and high soft tissue resolution with less artifacts from the dense orbital bones, provide much visualization of the orbital apex (7). The absence of ionizing radiation and contrast material is an additional benefit. MRI has to be the examination of choice to evaluate lesions with intra-cranial extensions (optic is an additional benefit. MRI has to be the examination of choice to evaluate lesions with intra-cranial extensions (optic). The absence of ionizing radiation and contrast media has been given to some patients to visualize the vascular structures of the orbit as well as to know the pattern of enhancement of some lesions.

(2) Magnetic resonance imaging: MRI examinations were performed using Gyroscan Philips 1 Tesla strength and used according to the following protocol:

MRI protocol for examination of the orbit included the following planes and sequences:

1. Axial T1 WI, T2 WI and SPIR (Selective Partial Inversion Recovery) T1 WI.
2. Coronal T2 WI.
3. Sagittal T1 WI.
4. Post Gd-DTPA, axial, coronal, sagittal TIWI and SPIR T1WI.
5. Diffusion-weighted MR imaging was obtained using a multislice single-shot echo planar imaging sequence (TR/ TE/NEX: 2200/139 ms/1) with b values of 0, 500, and 1000 s/mm². The signal intensity of the lesion on DWIs (b = 1000) was classified as hypointense (free diffusion) or hyperintense (restricted diffusion). The ADC maps were calculated automatically by the MRI software. Measurements of ADC were made in different regions of interest (ROI) of the lesions and the mean ADC value was calculated. The ADC values were expressed in 10⁻³ mm²/s.

The contrast used was Gd-DTPA: Gadolinium-Di-Ethylene-Triamine-Penta-Acetic acid, given intra-venous bolus injection in a dose of about 1 ml/ 5 kg with a maximum dose of about 10 ml and minimum dose of 3 ml.

After radiological examination, 24 patients were subjected to surgery and histopathology. Two patients were diagnosed with carotid cavernous fistula which was confirmed by angiography and referred for interventional radiology. 4 patients with orbital cellulitis were treated with systemic antibiotics of intra-muscular 1 g cefazidine every 8 h and oral metronidazole 500 mg every 8 h till the patient was apyrexial for 4 days.

4. Results

This study included 30 patients presented to the Ophthalmology and Radiology Departments at El-Minia University Hospital and El-Minia Oncology Center with clinical diagnosis of orbital masses and proptosis. They presented during the period from June 2012 to October 2013. 24 patients underwent surgical interference and pathological confirmation of which: Four patients of orbital pseudo-tumors, eight patients of cavernous hemangiomas, six patients with optic nerve gliomas, and six patients with optic nerve sheath meningiomas.

Most of the lesions were hypo intense signals on T1 WI except CC fistula that was signal void at all pulse sequences.

2. Causes of intra-conal orbital masses (7)

1. Optic nerve lesions:
   A. Optic nerve glioma.
   B. Optic nerve sheath meningioma.
   C. Neurilemmoma.
   D. Other optic nerve tumors.
2. Cavernous hemangioma.
4. Inflammatory lesions including infectious (abscess) and idiopathic orbital inflammatory disease (pseudo-tumors).
5. Other rare lesions including: Hemangiopericytoma, orbital mesenchymal chondrosarcoma and Fibrous histiocytoma.

3. Patients and methods

This study included 30 patients presented to the Ophthalmology department and referred to the Radiology Departments at El-Minia University Hospital and El-Minia Oncology Center with clinical diagnosis of orbital masses and proptosis. They presented during the period from June 2012 to October 2013.

All patients were subjected to complete ophthalmic examination including external appearance, best corrected visual acuity, slit lamp examination, fundus examination, IOP measurement, extra ocular muscle examination, and degree of proptosis by Hertel exophthalmometer.

These patients were subjected to:

(1) Multidetector Computed tomography: All MDCT examinations were performed using 16 detector CT scanner (GE bright speed). Reconstruction type: Standard bone window 3000/300 (WW/WL). Standard soft tissue window 400/50 (WW/WL). Axial thin sections were done firstly then coronal and sagittal reconstruction images were generated. 50 ml of water soluble contrast media was given to some patients to visualize the vascular structures of the orbit as well as to know the pattern of enhancement of some lesions.

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24 patients underwent surgical interference and pathological confirmation of which: Four patients of orbital pseudo-tumors, eight patients of cavernous hemangiomas, six patients with optic nerve gliomas, and six patients with optic nerve sheath meningiomas.

Most of the lesions were hypo intense signals on T1 WI except CC fistula that was signal void at all pulse sequences.
Pseudo-tumors and ON sheath meningiomas were hypointense on T2 WI while the abscess (characteristic hypointense wall on T2 WI), cavernous hemangiomas and gliomas were hyper intense on T2 WI. Dynamic contrast enhancement was
detected clearly on cavernous hemangiomas. Thick peripheral enhancement was detected on orbital cellulitis with abscess formation. So, from this table, the use of diffusion MRI technique can differentiate most of intra-conal mass lesions using the DWI and ADC map and its mean value.

So, coronal plane is the most important plane for accurate localization of intra-conal lesions having sensitivity of 95%, specificity of 80% and accuracy of 80%, followed by sagittal and axial planes.

So, diffusion WI is most valuable advanced MRI technique for evaluation of intra-conal orbital lesions having sensitivity of 95%, specificity of 90% and accuracy of 86%, followed by SPIR T1 WI at pre and post contrast studies.

5. Discussion

In this study, there were six patients with optic nerve gliomas (astrocytoma) presented in children, four females and two males, with axial proptosis and optic nerve atrophy. Four lesions were seen involving the intra-orbital and intra-canicular portions of the optic nerve while the other two lesions did not extend to intra-canicular portion and the optic nerve on the other side was noted thickened with early involvement in one patient. On CT, the ON appeared thickened and tortuous along its whole course with areas of degenerations (tumor infarctions). The lesions showed mild non-homogenous enhancement. The intra-canicular part could not be accurately evaluated. On MRI the tumor showed iso-to-hypointense signals on T1 WI and mixed hypersignals on T2 WI compared to gray matter of the brain. After Gd-DTPA injection, the lesion showed non-homogenous enhancement. Fat suppression technique (SPIR T1 sequence) was a suitable sequence to study the ON glioma and evaluates the intra-canicular as well as the intra-cranial extensions of the lesion accurately. On diffusion weighted imaging, the lesion was noted bright (restricted diffusion) with ADC value less than 1 mm$^2$/s (Fig. 1).

Wilhelm (2) and Kanski and Bowling (8) stated that MRI is the diagnostic imaging of choice for ON glioma including its...
intra-canalicular and intra-cranial extensions especially on SPIR T1WI sequence at pre and post contrast. Razek et al. (3) postulated that MRI diffusion played an important role in the differentiation between benign and malignant orbital masses and ON glioma showed restricted diffusion on DWI and its ADC value less than 1 mm²/s.

In this study, there were six middle aged patients, four females and two males, with optic nerve sheath meningiomas. All patients presented with insidious onset of visual loss, optic atrophy and gradual onset of painless unilateral proptosis. The lesions appeared on CT as well-defined homogenous mass lesion intra-conal at the retro-global space. Two lesions were noted encircling the nerve and the other lesions were noted eccentric in location and smaller but with dots of calcifications (important sign). The lesions showed moderate homogenous enhancement after contrast injection. On MRI, the lesions appeared well defined intra-conal and inseparable from the optic nerve, displaying hypointense signals at T1 and iso to hypointense signals on T2 WI compared to the gray matter of the brain. SPIR T1 WI was also important sequence. The lesions showed homogenous enhancement after contrast injection that was essentially to be done on fat suppression T1WI better than T1WI without fat suppression. Diffusion and ADC map were done and were also important (Fig. 2).

Menon et al. (9) stated that MRI findings of optic nerve sheath meningiomas were not as specific as those shown by CT because of the ability of CT to demonstrate calcifications. In our study, MRI was more accurate and specific in the evaluation of ON meningiomas especially intra-canaliculic and intra-cranial extensions with the use of SPIR T1 WI and Gd-DTPA injection as well as diffusion weighted images and this was postulated by Haddad et al. (4).

Umi Kalthum et al. (10) stated that MRI with recent techniques SPIR sequence and diffusion weighted images were essential for differentiating intra-orbital pseudotumors from optic nerve sheath meningioma.

Fig. 3 A 32 year old male presented with gradual onset of painless axial non-pulsating left sided orbital mass and unilateral proptosis. MDCT: Axial (A) and coronal (B) post contrast CT scans (soft tissue window) revealed a well-defined left orbital intra-conal homogeneously enhancing lesion (arrow) resting on optic nerve and displacing it as well as the left superior and medial recti muscles (lesion localization was more accurate on coronal scan). MRI: Axial T1WI (C) and T2 WI (D), coronal SPIR T1 pre (E) and post Gad (F): Showed a left well-defined homogenous space occupying lesion (arrow in C and D) at the retro-bulbar region. The lesion exhibits hypo signals on T1 WI and hyper signals on T2 WI. It takes patchy enhancement that was increased by time and became more homogenous on delayed scanning (on F). (Lt. intra-conal cavernous hemangioma).
In this study, there were eight patients diagnosed with cavernous hemangiomas. All patients were adults, 5 females and 3 males and presented with gradual onset of painless unilateral proptosis. On CT the lesions appeared as well-defined, smooth and well circumscribed homogenous mass lesions at the retro-orbital region. Four lesions were seen medial to and the others lateral to the optic nerve that was compressed by these lesions, also, the globe was displaced forward. After I/V contrast
injection, the lesions showed homogenous enhancements. On MRI, the coronal and sagittal planes with the fat suppression technique (SPIR T1) after Gd-DTPA and DWI were the most suitable planes and pulse sequences for accurate localization and evaluation of the cavernous hemangiomas. The lesions showed hypo to-isointense signals on T1 WI and hyperintense signals on T2 WI compared to gray matter of the brain. Dynamic contrast enhancement with fat suppression technique (SPIR T1), was essential to characterize cavernous hemangiomas. This pattern could not be detected on contrast enhanced CT. On DW MRI, the lesion showed bright signals (diffusion restriction) with ADC value 0.72 mm$^2$/s (Fig. 3).

Bertelmann et al. (11) demonstrated that most of the cases of cavernous hemangiomas were intra-conal and the lesions displayed iso to hypointense signals at T1 WI in gray matter of the brain with hyperintense signals on T2 WI.

Razek et al. (3) postulated that MRI diffusion can differentiate between benign and malignant orbital masses and cavernous hemangiomas showed restricted diffusion on DWI and its ADC value 0.72 mm$^2$/s.

In this research, there were two patients, one female and one male, diagnosed as direct carotid cavernous fistula with dilated and tortuous superior ophthalmic vein as well as prominent cavernous sinus. These findings were concluded by Phatouros et al. (12) and Bithal (13) and proved by him on doing angiographic evaluation.

There were four adult patients, 2 females and 2 males, with unilateral orbital pseudo tumors that were associated with intra-conal extensions. They were of chronic form and not responding to corticosteroid therapy. This is agreed by Kapur (14). Two of these four lesions were completely obliterating the retro-orbital fat and called sclerosing pseudotumor. This special type of pseudotumors was also concluded by Amin et al. (15).

### Table 1 Pathological diagnosis of 24 patients with orbital mass lesions.

<table>
<thead>
<tr>
<th>Pathological diagnosis</th>
<th>No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflammatory Pseudotumors</td>
<td>4</td>
</tr>
<tr>
<td>Vascular lesions</td>
<td>8</td>
</tr>
<tr>
<td>Cavernous hemangioma</td>
<td>6</td>
</tr>
<tr>
<td>Iry optic nerve sheath meningioma</td>
<td>6</td>
</tr>
<tr>
<td>Optic nerve gliomas</td>
<td>6</td>
</tr>
<tr>
<td>Total Lesions</td>
<td>24</td>
</tr>
</tbody>
</table>

### Table 2 Signal intensity and pattern of contrast enhancements of intra-conal orbital lesions.

<table>
<thead>
<tr>
<th>The lesion</th>
<th>T1 WI</th>
<th>T2 WI</th>
<th>SPIR T1</th>
<th>Enhancement</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Abscess</td>
<td>Hypo-intense</td>
<td>Hyper</td>
<td>Hyper</td>
<td>Peripheral and mild</td>
</tr>
<tr>
<td>*Pseudotumor</td>
<td>Hypo-intense</td>
<td>Hyper</td>
<td>Hyper</td>
<td>Homog</td>
</tr>
<tr>
<td>*CC fistula</td>
<td>Signal void</td>
<td>Signal void</td>
<td>Signal void</td>
<td>Intense</td>
</tr>
<tr>
<td>*Cavernous hemangioma</td>
<td>Hypo</td>
<td>Hyper</td>
<td>Hyper</td>
<td>Patchy and dynamic</td>
</tr>
<tr>
<td>*ON sheath meningioma</td>
<td>Hypo-isol</td>
<td>Hypo</td>
<td>Hyper</td>
<td>Mild homogenous</td>
</tr>
<tr>
<td>*ON glioma</td>
<td>Hypo-intense</td>
<td>Hyper</td>
<td>Hyper</td>
<td>Non-homogenous</td>
</tr>
<tr>
<td>Total</td>
<td>4 hypo + 1 hypo + 3 hyper + 1 signal void</td>
<td>5 hyper + 1 signal void</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 3 Value of diffusion weighted imaging in evaluation of intra-conal orbital lesions.

<table>
<thead>
<tr>
<th>Lesion</th>
<th>Number</th>
<th>DWI ($P$ value 1000)</th>
<th>Mean ADC value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abscess</td>
<td>4</td>
<td>Bright</td>
<td>1.5</td>
</tr>
<tr>
<td>Cavernous hemangioma</td>
<td>8</td>
<td>Bright</td>
<td>0.72</td>
</tr>
<tr>
<td>Optic nerve glioma</td>
<td>6</td>
<td>Bright</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>ON sheath meningioma</td>
<td>6</td>
<td>Bright</td>
<td>&gt;1.0</td>
</tr>
<tr>
<td>Pseudotumors</td>
<td>4</td>
<td>2 bright and 2 hypointense</td>
<td>1.4–1.9</td>
</tr>
</tbody>
</table>

### Table 4 Suitable plane for accurate lesion localization.

<table>
<thead>
<tr>
<th>Plane</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial</td>
<td>55</td>
<td>66</td>
<td>71</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Coronal</td>
<td>95</td>
<td>80</td>
<td>81</td>
<td>66</td>
<td>80</td>
</tr>
<tr>
<td>Sagittal</td>
<td>90</td>
<td>70</td>
<td>76</td>
<td>50</td>
<td>73</td>
</tr>
</tbody>
</table>

Note: PPV = positive predictive value, NPV = negative predictive value.
On DW MRI, two lesions showed hypointense signals (no diffusion restriction) and the other two lesions showed high signal (diffusion restriction) with ADC value more than 1.4 and this was postulated by Nader et al. (6).

Kapur et al. (14) concluded that MRI with diffusion images was essential in the diagnosis of orbital pseudotumors and differentiating it from other orbital lesions.

In this study, there were four children patients, 3 males and one female, with infectious orbital lesions. Two involved the intra-conal region (orbital cellulitis) and were presented with constitutional symptoms and progressive painful unilateral proptosis associated with severe local tenderness and visual loss as well as painful ophthalmoplegia. Mild adjacent sinus disease was noted. On CT, it showed a well-defined intra-conal space-occupying lesion. The lesions could not be separated from the inferior rectus muscle and the optic nerve was seen displaced. Mild diffuse contrast enhancement is seen. On MRI, the lesions showed hypointense signals at T1 WI compared with gray matter of the brain and showed hyperintense signals at T2 WI especially its central part. After Gd-DTPA injection, the lesions become more defined with peripheral thick and enhancing wall as well as central cystic liquefied non-enhancing part (abscess formation) (Fig. 4). The lesions were due to complicated sinusitis and responded to antibiotics. On DWI, the central liquefied portion of the lesion showed diffusion restriction.

Davis and Hopkins (16) concluded that MDCT was preferred to MRI in cases of orbital cellulitis as the orbital tissues had high CT contrast and the bone as well as sinuses can be visualized better. Tasman et al. (17) described that MDCT scan on cases of orbital cellulitis should be recommended to rule out the possibility of foreign body with orbital cellulitis. MRI was mandatory in patients not responding to massive antibiotics to exclude the early affection to the optic nerve. MRI was essential in the diagnosis of orbital pseudotumors and differentiating it from other orbital lesions.

Table 5 Suitable sequence for more characterization.

<table>
<thead>
<tr>
<th>MRI sequence</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional MRI</td>
<td>56</td>
<td>50</td>
<td>84</td>
<td>18</td>
<td>55</td>
</tr>
<tr>
<td>SPIR T1WI</td>
<td>80</td>
<td>76</td>
<td>73</td>
<td>46</td>
<td>76</td>
</tr>
<tr>
<td>Diffusion W MRI</td>
<td>95</td>
<td>90</td>
<td>78</td>
<td>50</td>
<td>86</td>
</tr>
</tbody>
</table>

6. Conclusions

We concluded that the application of recent MRI techniques like diffusion WI and ADC map in addition to the conventional sequences especially SPIR (selective partial inversion recovery) was essential to accurate diagnosis of intra-conal orbital mass lesions as well as MDCT was important when the lesions show areas of calcifications or related to orbital bony walls. So, the MRI with its recent techniques and MDCT are complementary for most of the intra-conal orbital lesions.

Conflict of interest

We have no conflict of interest to declare.

Disclosure

No disclosure of funding received for this work from any organization.

Authors contribution

All authors have apprised the article and actively contributed to the work. Hoda Abdel Kareem: Data collection and Image revision. Manal F. Abou Samra: Data collection and final editing. Mohamed Farouk Osman: Final editing and revision.

References

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