Orbital Imaging Modalities and Recent Updates

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KEYWORDS

• Orbital anatomy • Ultrasonography • Computed tomography • Magnetic resonance imaging • PET-CT

KEY POINTS

- Knowledge in complex orbital anatomy is essential in recognizing orbital pathology on imaging.
- Imaging is often necessary to assess retrobulbar pathology as this area cannot be reliably assessed by clinical ophthalmologic examination alone.
- Various imaging modalities including ultrasound (US), computed tomography (CT), MR, PET-CT are available and play complementary role with each other.
- Continued technical evolution contributed to recent updates on each imaging modality, further emphasizing clinical utilities of imaging examinations.

INTRODUCTION

Orbit is a small space; however, it contains many crucial anatomic structures, not only contributing to vision, the vital function, but also in protecting its own orbital contents to maintain the function.

There is a broad spectrum of pathologies that originate from the orbit proper as well as arising from the adjacent structures affecting the orbit. Some of these pathologies are visible externally and ophthalmologic examination plays a crucial role. On the other hand, some of the pathologies, especially in the retrobulbar location, can be difficult to assess the entire extent by physical examination alone, for which orbital imaging is useful.

Orbital imaging is usually performed with special dedicated protocols including thin slice thickness images with multiplanar reconstruction due to its unique cone-shaped anatomy and small delicate contents. In addition, different imaging modalities play complementary roles in evaluating its substructures. In this article, we will go over each imaging modality used in orbital imaging as well as their recent technological updates.

DISCUSSION

Orbit

The orbit is an interesting anatomic structure which is confined by complex cone-shaped bony walls and nerve foramina (**Fig. 1**). Multiple different bones form bony orbit, including frontal, ethmoid, zygomatic, maxilla, lacrimal, palatine, and sphenoid bones.[1]

Within the orbit, there are multiple extraocular muscles coordinating delicate ocular movement. In terms of its neural contents, optic nerve is coursing in the center of intraconal space, which is an extension of central nervous system not enveloped by Schwann cells. Cranial nerve III, IV, V and VI which are part of peripheral nervous system lined by Schwann cells also course within the orbit.

Orbit contains unique anatomic structures that are not present elsewhere in the rest of the body, such as orbital globe. Thanks to the evolving imaging techniques, some of the globe linings are visible on high resolution orbit MR, with choroid/uveal layer visible on high resolution postcontrast MR as thin enhancing layer, and the outer most

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Abbreviations

^{18}F-FDG	^{18}Fluoride-fluorodeoxyglucose
^{18}F-NaF PET	^{18}F-sodium fluoride PET
3D	3-dimensional
ASL	arterial spine labeling
CT	computed tomography
CTV	computed tomography venogram
DCE	dynamic contrast enhanced
DSA	digital subtraction angiography
DWI	diffusion-weighted image
MRA	MR angiogram
TOF	time of flight
US	ultrasound

sclera layer visible as a hypointense layer on T1-weighted as well as T2-weighted images.[1]

Lacrimal apparatus is another unique structure, secreting, controlling and draining tears to lubricate and protect the orbital structures (**Fig. 2**). Lacrimal gland is considered an exocrine gland which contains plasma cells and lymphocytes histologically.[2]

A detailed review of orbital anatomy will be provided in the subsequent Orbital Anatomy article. As we can infer from above, orbital anatomy is complex. Therefore, appropriate orbital imaging is beneficial in depicting this complex anatomy, mapping important anatomic landmarks especially for preoperative planning, as well as in recognizing pathology especially retrobulbar process which may be difficult to evaluate solely by ophthalmologic examination, while clinical history and ophthalmologic examination remain as essential part of orbital assessment.

Imaging Modalities

Ultrasound

Ultrasound (US) is a useful tool in assessing superficial orbital structures, although it is more commonly used by ophthalmologists than by radiologists. One of the well-known techniques is Ossoinig's standardized echography suggested by Dr Karl Ossoinig, where the combination of A-scan, B-scan and Doppler US scan, enables reliable assessment of the optic nerve and extraocular muscles and can evaluate the posterior segment pathologies.[3,4] US has an advantage of its real-time examination capacity, although it is highly dependent on operator experience, limiting standardization and universal accessibility.

In cases of periorbital/eyelid melanoma or non-melanomatous skin cancer such as squamous cell carcinoma or sebaceous carcinoma, regional and/or cervical nodal metastases can often occur. For example, the incidence of nodal metastasis is reported in up to 24% of eyelid squamous cell carcinomas.[5] Among the nodal stations, intraparotid and periparotid nodal stations are reported to be most frequently involved, followed by submandibular and jugular chain nodal stations.[5–7] These suggest intraparotid and periparotid nodal stations may be a gateway for further disease spread below the facial level, necessitating careful evaluation of cervical nodes. Furthermore, the presence of parotid and/or cervical nodal metastasis would alter the management plan including the need for parotidectomy, extent of neck dissection, and need for adjuvant radiation treatment. Luckily, most of these areas are superficially located and can be efficiently assessed by US.

At our institution, a US neck nodal survey examination routinely includes lateral neck compartments from the supraclavicular region up to the superior neck and submandibular regions, the posterior triangle, as well as the central neck compartment. In cases of head and neck cutaneous malignancy including squamous cell carcinoma or melanoma, we also include parotid, periauricular and suboccipital regions in addition to a routine neck survey protocol. In addition, if the patient has a palpable abnormality, US is useful for focused evaluation at the area of interest.

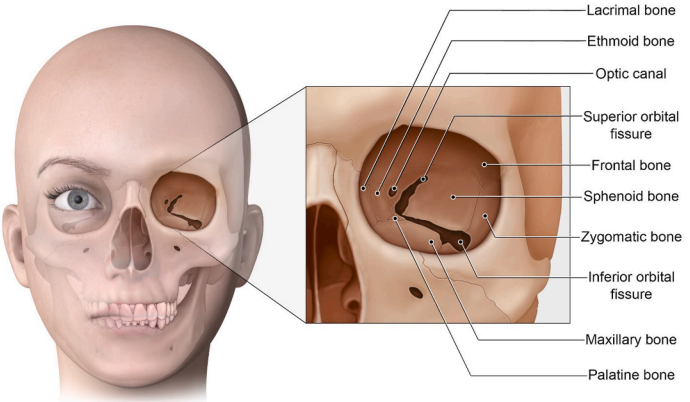

Fig. 1. Orbital bony anatomy illustration showing multiple bones comprise bony orbital walls. Bony foramina including optic canal, superior orbital fissure, and inferior orbital fissure are also depicted. (*Image Courtesy* Kelly Kage, MFA, CMI.)

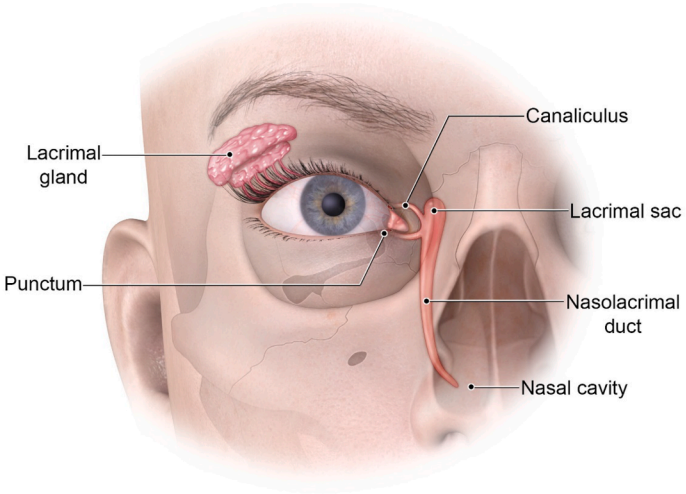

Fig. 2. Illustration of lacrimal apparatus, a unique structure seen in the orbit. Tears produced in lacrimal gland travels along the ocular surface and drains sequentially via punctum, canaliculi, lacrimal sac, nasolacrimal duct, and eventually into nasal cavity. (*Image Courtesy* Kelly Kage, MFA, CMI.)

Frequently, we perform same-day fine needle aspiration and/or core needle biopsy if a suspicious morphology lymph node or a lesion is detected at the time of diagnostic US. Then, sampled tissues are simultaneously reviewed by a cytologist for adequacy to ascertain a diagnostic quality of sampled tissue, before the patient is released from our institution. This approach has multiple benefits for the patient: increased convenience, decreased scheduling conflicts by reducing the need for a return visit on different date for a repeat procedure, decreased rates of nondiagnostic samples, and expediting clinical management by shortening overall time spent on diagnosis and staging workup (**Fig. 3**).

Plain radiograph and computed tomography

Plain radiograph and conventional computed tomography Nowadays plain radiograph is often used to screen foreign bodies in orbital regions, especially to rule out metallic foreign bodies before MR when patient has a pertinent history.

Computed tomography (CT) is one of main modalities used not only to assess the presence of orbital pathology, but also to help characterize the process. It is a preferred tool in facial-orbital trauma or other urgent indications, as CT is easily accessible compared to MR, with a quicker acquisition time especially using modern multidetector technology and enabling multiplanar reconstruction in any plane deemed necessary. Additionally, CT is useful in evaluating integrity or lesion involvement of the bony orbital wall. Relatively large amounts of inherent background fat content in orbital space aids in detection of soft tissue mass in orbital space by inherently providing contrast from default background hypodensity.

At our institution, CT of the orbit is obtained from the top of the frontal sinus down to maxilla level. It

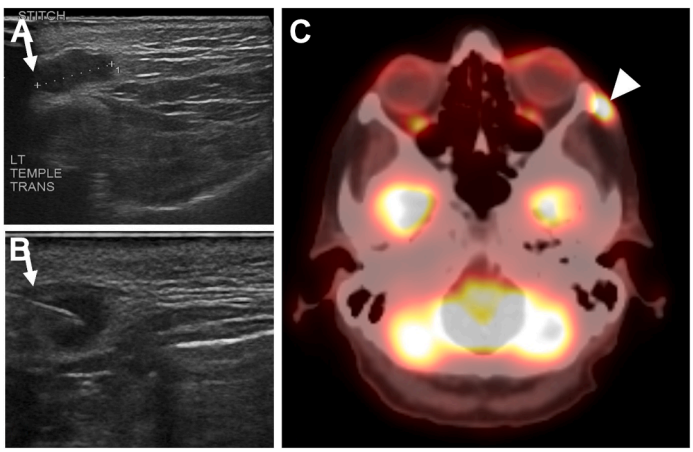

Fig. 3. Patient with history of lateral canthus melanoma, with new subcutaneous nodule on dermatologic examination. Punch biopsy performed at dermatology clinic was negative for melanoma. (*A*) US image shows 1.1 cm hypoechoic subcutaneous nodule in left temple near surgical scar (*arrow*). (*B*) Simultaneously performed US guided fine needle aspiration of the nodule was positive for melanoma (*arrow*). (*C*) Subsequent ^{18}F-FDG PET-CT demonstrates FDG avidity at the site of biopsy proven melanoma recurrence in left temple (*arrowhead*).

is usually acquired in bone and soft tissue algorithm with 1.25 mm or 1.5 mm slice thickness and multiplanar reconstruction images are often made in 0.625 mm slice thickness, balancing spatial resolution and signal-to-noise ratio.

Computed tomography angiogram and computed tomography venogram Oftentimes, orbital–periorbital pathology can be of vascular etiology or closely associated with adjacent vascular structures, necessitating vascular imaging for further investigation. For example, vascular imaging is helpful in detection and characterization of orbital cavernous malformation, hemangiopericytoma, venous varix (with a Valsalva maneuver), arteriovenous fistula/carotid-cavernous fistula, other various types of vascular malformations, and ophthalmic artery aneurysm.[8] In addition, vascular imaging may be useful in assessing tumor vascularity, identifying tumor feeding arteries as well as draining veins, and locating landmark vessels for preoperative vascular mapping when surgical treatment is planned for known orbital tumors.

The gold standard diagnostic tool is digital subtraction angiography (DSA) which can accurately depict vascular anatomy and temporal vascular flow dynamics. It can also provide endovascular treatment as indicated. However, this requires arterial puncture harboring small but nonnegligible risk of bleeding, thrombus, iatrogenic dissection, pseudoaneurysm or arteriovenous fistula formation. In this context, CT based vascular imaging is a good noninvasive alternative option for baseline diagnostic purpose or follow-up of known or treated lesions, unless the patient has a contraindication to iodinated contrast media.

CT arteriography is focused on arterial structure assessment, in which imaging at the peak arterial phase following intravenous contrast administration is essential before venous contamination dominates. To achieve this, most institutions use a bolus tracking technique.

On the other hand, CT venogram (CTV) aims at venous structure assessment by obtaining images in the venous phase. Additional post-processed images are typically provided with bone subtraction and 3-dimensional (3D) multiplanar reconstruction, which are helpful in conjunction with raw image interpretation. Variation in CTV protocol can be made when orbital venous varix is suspected. In this case, noncontrast orbit CT in resting status can be first obtained, followed by CTV with provocative maneuvers—commonly Valsalva maneuver—that cause elevated venous pressure resulting in characteristic dynamic appearance of venous varix on imaging[8] (**Fig. 4**).

Cone beam computed tomography Cone beam CT is a relatively new technique which is being explored for its clinical utilities. Images are generated by cone-shaped radiograph beam detected by 2-dimensional detectors, while conventional CT is acquired by fan shaped radiograph beam detected by 1-dimensional detector. This allows reduction in number of gantry rotations during image acquisition, which in turn saves imaging time. It is also advantageous in that patient radiation dose is lower than that of conventional CT.[9] High spatial resolution and 3D volume rendering capacity are other strengths of cone beam CT.

However, there are drawbacks of cone beam CT mostly derived inherently from the above-mentioned imaging acquisition principle. These include under sampling error, imaging distortion resulted from unequal degree of radiograph attenuation between the center and periphery of the patient, increased scatter radiation with decreased signal to noise ratio and decreased soft tissue contrast resolution,[9] which limits evaluation for soft tissue structures.

Cone beam CT has been clinically applied in dentistry,[9] breast imaging,[10] and imaging guidance for interventional radiology procedures,[11] taking advantage of its accuracy and 3D reconstruction ability in relatively short acquisition time.

In terms of orbital imaging, cone beam CT has also been attempted experimentally, for example, in bony orbital wall integrity assessment in trauma,[12] and relationship of radio-dense graft and bony wall evaluation following orbital reconstruction surgery.[13] Its potential utilities in quantitative measurement of orbital volume[14] and evaluation of bony orbit anatomic landmarks, such as the infraorbital canal[15] have also been reported. In some of these reported cases, cone beam orbit CT produced acceptable quality images for osseous structure evaluation with decreased radiation dose, which has merit over conventional CT, considering the risk of cataract development following repetitive cumulative radiation to the ocular lens. In addition, Raz and colleagues reported that the central retinal artery could be detected on cone beam CT in the orbit region obtained with DSA suggesting its potential role in delicate orbital vessel evaluation, although the study was performed in only small number of patients.[16] However, it needs to be kept in mind that cone beam CT is inferior in the evaluation of soft tissue anatomic structures, characterization of soft tissue mass, and orbital hematoma.[12] Therefore, further validation studies in larger number of cases and careful scrutinization of indication for cone beam CT will be necessary before universal clinical application.

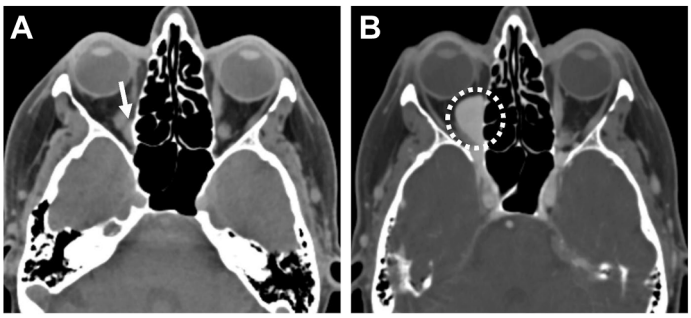

Fig. 4. Patient with history of lymphoma with new orbital mass reported on surveillance neck CT. (*A*) Noncontrast orbit CT in resting status shows minimal soft tissue fullness in right orbit near the orbital apex (*arrow*). (*B*) Postcontrast orbit CT with Valsalva maneuver shows enlarged enhancing mass in right orbit which has similar density as the vessels (dashed circle). This dynamic appearance is most consistent with orbital venous varix and imaging with a provocative maneuver helps clenching the diagnosis.

Photon Counting computed tomography This new emerging CT technique is becoming popular due to its superior spatial and contrast resolution with decreased noise allowing for sharper crisp images optimal to assess minute delicate structures. There are additional benefits of reduced radiation dose and decreased iodine contrast dose needed. These advantages over conventional CT were facilitated by key differences in radiograph detectors. Unlike conventional CT with a scintillator where radiograph beams are converted to light then to electronic signals, photon counting CT uses a semiconductor with voltage across, converting incoming radiograph photons directly to an electronic signal; by skipping the middle light conversion step, septa-related dead space related problems are resolved while achieving smaller pixel size.[17] Another powerful advantage of photon counting CT is multi-energy spectral imaging which has potential applications such as in material composition evaluation or in vascular imaging by reducing calcification related artifacts or with virtual noncalcium mapping.[17,18] There is a reported potential utility of photon counting CT in orbital arterial imaging,[19] although there remain technical limitations and data in orbital imaging application in general is sparse, requiring further elucidation.

MRI

Since MRI was first applied to human subjects in the 1970s by Damadian and colleagues,[20] MRI has been rapidly evolving and has become the pinnacle of modern medical imaging. MRI's excellent soft tissue characterization property enhances its strength, and MR is often an eventual problem-solving radiologic modality in many clinical scenarios, while also playing complementary role to other imaging modalities. This is not an exception in orbital imaging; MR is an important diagnostic tool especially to assess fine structures in the orbit proper as well as around the orbit that can affect orbital structure functions.

Basic orbit MR sequences include T1- and T2-weighted images with and without fat saturation and fat-saturated postcontrast T1-weighted images with axial, sagittal and coronal planes through the orbit; coronal plane is particularly contributory in orbital imaging compared to the other parts of body as it enables better orthogonal plane evaluation of extraocular muscles and optic nerve sheath complexes, as well as evaluation of paired orbital structure symmetry. At our institution, we also obtain a separate T2 fat suppressed sequence through the neck for nodal survey purposes where sometimes cervical nodal metastasis or cervical spine metastasis can be detected.

Diffusion-weighted images In addition to above mentioned basic sequences, there are advanced and newer sequences that are often used and aid in diagnosis. One example is diffusion-weighted image (DWI) sequence, where hypercellular tissue exhibits restricted diffusion with a decreased apparent diffusion coefficient value and high signal intensity on the DWI sequence due to decreased degree of Brownian motion of its water content. As elsewhere in body, malignant masses tend to have high cellularity and restricted diffusion unless there is significant necrosis, or a cystic or mucinous component (**Fig. 5**). This appearance on DWI in conjunction with other imaging parameters can aid in diagnosis of malignancy such as orbital lymphoma apart from those with a benign etiology.[21,22]

DWI is useful in detecting ischemic changes in brain. In addition, there have been sporadic reports of diffusion abnormalities in ischemic optic neuropathy.[23,24] However, the overall reported number of cases are small due to technical difficulties related to small size target structure, artifact prone location, relatively rarity of ischemic optic neuropathy acquiring MR imaging, and false positive potentially from acute optic neuritis related to demyelinating disorders.[24]

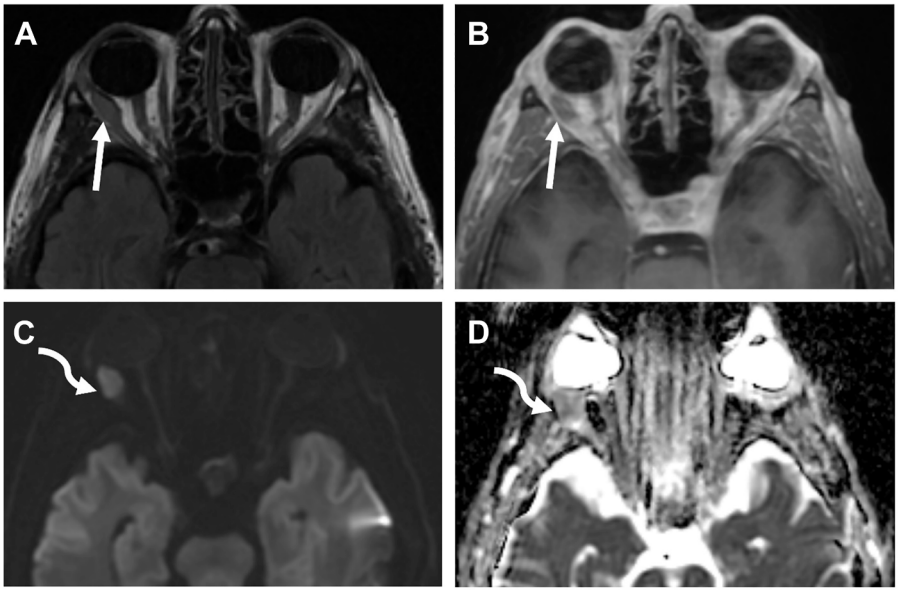

Fig. 5. Surveillance brain MRI in patient with history of melanoma. Fluid attenuated inversion recovery (FLAIR) sequence (*A*) and postcontrast T1-weighted images (*B*) show subtle asymmetric thickening of right lateral rectus muscle (*arrow*), which can easily be overlooked. High b-value DWI images (*C*) and apparent diffusion coefficient map (*D*) more clearly demonstrate diffusion restricting lesion in right lateral rectus muscle (curved *arrow*), corroborating suspicion for metastatic deposit. Patient then underwent radiation therapy.

DWI sequences are also helpful in detecting extraocular lesions in the included portion of intracranial compartment, bony structures, neck soft tissue, and intraparotid or cervical adenopathy, that can be subtle or overlooked in other sequences (**Fig. 6**). While these diffusion restricting lesions are worth further attention to exclude metastasis or other hypercellular process, especially in patients with underlying malignancy, these diffusion signal abnormalities cannot be fully characterized solely

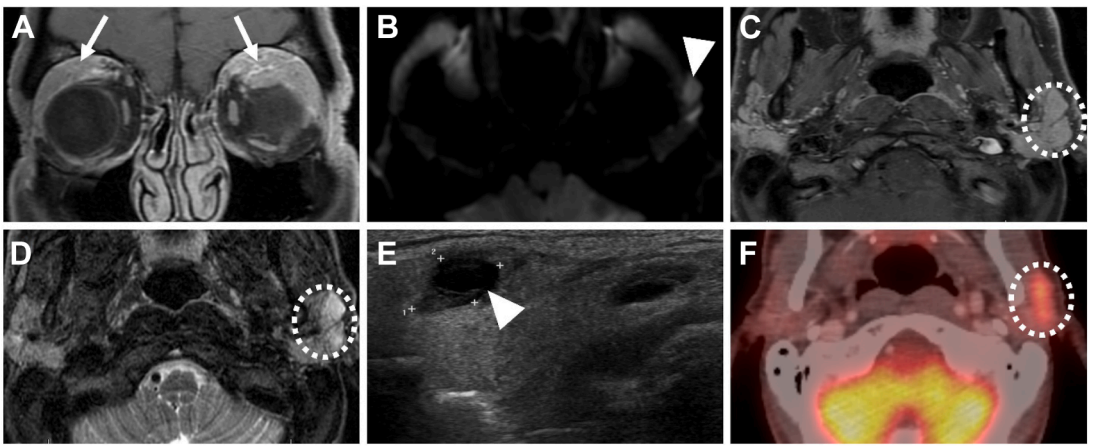

Fig. 6. Patient with orbital lymphoma. (*A*) coronal postcontrast T1-weighted image shows infiltrative enhancing tissue in bilateral superior–lateral extraconal orbits (*arrows*), in keeping with lymphoma. (*B*) High b-value DWI image on orbit MR additionally shows asymmetrical diffusion restricting foci in left parotid (*arrowhead*). Postcontrast T1-weighted image (*C*) and T2-weighted image (*D*) show subtle left superficial parotid nodules with mild T2 hyperintensities and enhancement similar degree to background parotid parenchyma (dashed circles), corresponding to diffusion abnormalities. (*E*) US image of left parotid shows abnormal morphology adenopathy with eccentric bulbous cystic-hypoechoic component (*arrowhead*). Simultaneous fine needle aspiration confirmed lymphoma involvement. (*F*) Subsequence FDG^{18} PET-CT show corresponding FDG avidity (dashed circle).

by DWI as it is nonspecific, and careful evaluation on all other sequences is warranted.

Steady state MR This is one of the useful sequences in fine anatomic structure and small lesion evaluation, which are available as Constructive Interference in Steady-State (from Siemens) and Fast Imaging Employing Steady-state Acquisition-C (from GE HealthCare) depending on the venders. These provide heavily T2-weighted high-resolution images with 3D reconstruction, particularly helpful in evaluation of fine detailed structures within the brainstem and along cranial nerves in skull base leading to orbital pathology[25] (**Fig. 7**).

Perfusion MR There are 3 types of commonly used perfusion MR techniques; these include arterial spine labeling (ASL) technique, dynamic susceptibility contrast perfusion, and dynamic contrast enhanced (DCE) perfusion. In the orbital structures, ASL and DCE perfusion techniques have been applied sporadically.

ASL differs from the other perfusion imaging techniques in that it does not need intravenous contrast, which is an added advantage especially for patients who have a contraindication to gadolinium contrast. This technique indirectly estimates cerebral blood flow by comparing images of magnetically labeled blood influx with control static signals. Its potential utility with and without combination of DWI in distinguishing benign orbital inflammatory pseudotumor versus malignant lymphoma was reported.[22] However, orbital location itself is tricky to apply ASL routinely as susceptibility artifacts from adjacent bone and paranasal sinus air can hinder consistent production of reliable images.[26]

DCE technique is based on T1-weighted images, tracking the signal before and following the administration of intravenous contrast. By this dynamic data acquisition, DCE not only shows contrast uptake and washout pattern of target area graphically but also provides quantitative measure of tissue permeability and blood flow. In orbit, DCE by itself and/or in combination with DWI have been applied in lesion characterization. Many reported studies proved its usefulness in distinguishing malignant etiology from benign entity, by time intensity curve pattern analysis as well as by quantitative perfusion parameters derived from the DCE technique.[27–31] Jost and colleagues, also suggested DCE may play a role in predicting more clinically aggressive behavior of optic pathway glioma in pediatric populations.[32] However, there was heterogeneity in malignant tumor types included in each study, as well as heterogeneity in perfusion parameters proven useful in each study. In addition, a study conducted by Russo and colleagues raised a question on efficacy of routine inclusion of DCE in orbital multiparametric MRI, as DCE requires additional time

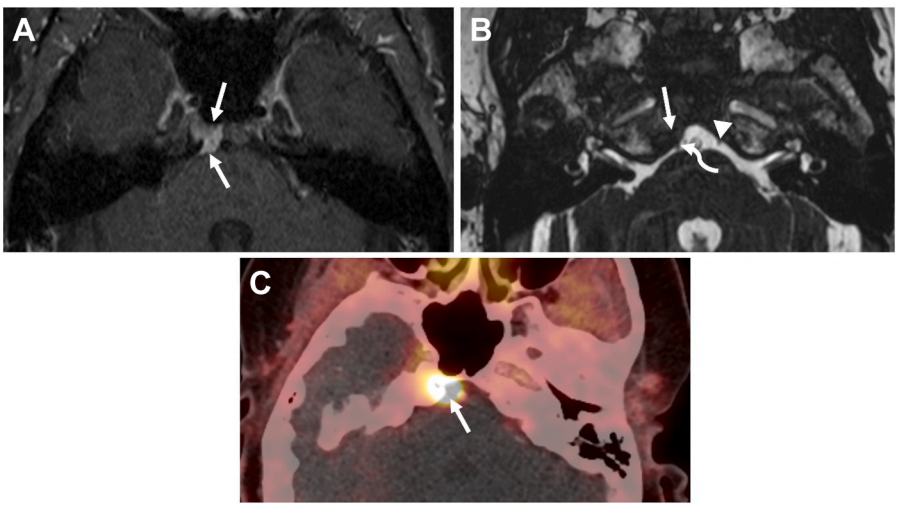

Fig. 7. Patient with remote history of tuberculum sella meningioma resection. (*A*) Postcontrast T1-weighted image of skull base MR show subtle right petroclival dural-based enhancing lesion (*arrows*), suspicious for meningioma. (*B*) High-resolution FIESTA-C image of skull base MR depicting the enhancing lesion extension along the right Dorello canal (*arrow*) and abutting the cisternal segment of right cranial nerve VI with slight medial deviation (curved *arrow*), compared to the unaffected left cranial nerve VI (*arrowhead*). (*C*) Subsequent ^{68} Ga DOTATATE PET- CT demonstrates corresponding DOTATATE avidity (*arrow*), corroborating the presence of meningioma. Subsequent clinical examination revealed right cranial nerve VI paresis. *Abbreviation*: FIESTA-C, Fast Imaging Employing Steady-state Acquisition-C.

spent on postprocessing while it may not alter diagnosis that already can be derived from other sequences, with exception of vascular lesions where dynamic contrast flow pattern may be helpful.[33] For these reasons, DCE can play a complementary role in orbital imaging, but it should be kept in mind that it may prove benefit only in a subset of patients.

MR angiogram Most MR angiograms (MRAs) performed for general vascular evaluation indication is with time of flight (TOF) sequence that obviates the need for intravascular contrast for general vascular evaluation indication. TOF MRA is useful in investigating vascular cause for ophthalmologic pathology such as aneurysm exerting a mass effect on cranial nerves, carotid-cavernous sinus fistula, or large vessel occlusion supplying orbital structures. It is also helpful in laying out vascular anatomy for preoperative evaluation, or as an alternative to CT angiogram when patient has contraindication to intravenous iodine contrast.

4D dynamic contrast enhanced MRA is often used as well, particularly for vascular malformations/lesions.[25,34] Multiple images in the area of interest are obtained in a short time interval following intravenous contrast injection, visualizing temporal dynamics of blood flow and vascularity of the mass that can contribute to better characterization of mass. In addition, this technique enables pertinent vascular anatomy assessment such as arterial feeder identification or venous drainage pattern recognition, further aiding in treatment planning in noninvasive method.

PET

PET is a functional quantitative imaging using a radioactive tracer. Modern PET is usually combined with either CT or MR to provide both anatomic and functional information. There are multiple different PET-tracers with different target properties. Among these, ^{18}Fluoride-fluorodeoxyglucose (^{18}F-FDG) is the most commonly used in clinical practice detecting hypermetabolic cells. This is particularly useful in oncologic imaging as many types of tumor cells are hypermetabolic, hence can be detected on ^{18}F-FDG PET imaging, not only in locoregional disease, but also distant metastasis detection, allowing for whole body staging. However, there are pitfalls to be aware of which can result in false positives from hypermetabolism related to infection/inflammatory/reactive etiology, sarcoidosis/sarcoid-like reactions, or physiologic activities from brown fat or muscular activities. In addition, there can also be false negatives from ^{18}F-FDG occult tumors such as renal cell carcinoma, hepatocellular carcinoma, carcinoid, low-grade tumors or tumors with predominantly necrotic or cystic or mucinous components.[35]

^{18}F-FDG PET imaging serves similar roles in orbital disease evaluation. Multiple different tumors of primary orbital origin as well as secondary orbital metastasis can be picked up, including lymphoma, carcinomatous deposits from various origins, melanoma, optic nerve glioma, and sarcoma.[36] This can also be helpful in evaluating noncancerous processes involving orbit such as immunoglobulin G4-related disease, inflammatory pseudotumor or granulomatous/infectious disease entities.

Osseous disease processes including fibrous dysplasia and osseous metastases can show increased tracer uptake on ^{18}F-sodium fluoride PET (^{18}F-NaF PET) which targets specifically bone structures yielding high sensitivity and specificity for bone disease evaluation.[36,37] ^{18}F-NaF PET plays complementary role to ^{18}F-FDG PET when there is ^{18}F-FDG occult tumor, and conversely ^{18}F-FDG PET may be able to detect lesions without significant blastic reaction that can be missed on ^{18}F-NaF PET.[37]

Somatostatin analog PET is another radiotracer imaging gaining popularity particularly for neuroendocrine tumor imaging, quickly becoming a commonly used tool for staging. Among available tracers targeting somatostatin receptors, ^{68} Ga tagged to a somatostatin analog chelated by 1,4,7,10-Tetraazacyclododecane-1,4,7,10-tetraacetic acid (DOTA) is commonly used (^{68}Ga-DOTATATE PET/CT). Its high sensitivity and specificity in detection of neuroendocrine tumors throughout the body have been reported.[38] Additionally, several cases of orbital neuroendocrine metastatic deposits with radiotracer avidity on somatostatin analog PET-CT were reported.[39] Interestingly, there are other types of tumors that can also express somatostatin receptors, hence can show avidity on somatostatin analog PET, such as neuroblastoma, pheochromocytoma, paraganglioma, and meningioma including optic nerve sheath meningioma[38,40](**Fig. 7**).

SUMMARY

The orbit is one of the unique anatomic structures where many different types of pathology can arise in a compact space which can lead to devastating vision symptoms. Orbital imaging plays a critical role in identification and characterization of pathology, helps clinicians guiding management, and is becoming more sophisticated with ever evolving technological advancements. Familiarity with the different imaging modalities and their strengths

and drawbacks, different protocols and new technologies allow radiologists to further contribute to optimal management for patients.

CLINICS CARE POINTS

- Imaging can be used in detection of orbital pathology, guiding biopsy for tissue diagnosis and post-treatment monitoring.
- Various imaging modalities are available for orbital pathology assessment with ever evolving technology increasing clinical value.
- Understanding the strengths and weaknesses of each modality is essential in choosing the optimal imaging examination for one's purpose.

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DISCLOSURE

The author has no conflicts of interest to disclose.

REFERENCES

1. Reinshagen KL, Massoud TF, Cunnane MB. Anatomy of the orbit. Neuroimaging Clinics 2022;32(4):699–711.
2.. Obata H. Anatomy and histopathology of the human lacrimal gland. Cornea 2006;25(10 Suppl 1): S82–9.
3.. Ossoinig KC. Standardized echography: basic principles, clinical applications, and results. Int Ophthalmol Clin 1979;19(4):127–210.
4. Byrne SF. Standardized echography of the eye and orbit. Neuroradiology 1986;28:618–40.
5. Faustina M, Diba R, Ahmadi MA, et al. Patterns of regional and distant metastasis in patients with eyelid and periocular squamous cell carcinoma. Ophthalmology 2004;111(10):1930–2.
6. Chebib E, Rougier G, Dubray-Vautrin A, et al. Lymph node evolution in eyelid and orbit squamous cell carcinomas. Laryngoscope 2024;134(12):4956–63.
7. Hashimoto K, Yasumatsu R, Toh S, et al. Patterns of lymphatic spread and the management of eyelid carcinomas. Auris Nasus Larynx 2016;43(6):666–71.
8. Smoker WRK, Gentry LR, Yee NK, et al. Vascular lesions of the orbit: more than meets the eye. Radiographics 2008;28(1):185–204.
9. Scarfe WC, Farman AG. What is cone-beam CT and how does it work? Dent Clin North Am 2008;52(4): 707–30.
10. He N, Wu YP, Kong Y, et al. The utility of breast cone-beam computed tomography, ultrasound, and digital mammography for detecting malignant breast tumors: a prospective study with 212 patients. Eur J Radiol 2016;85(2):392–403.
11. Wallace MJ, Kuo MD, Glaiberman C, et al, Technology Assessment Committee of the Society of Interventional Radiology. Three-dimensional C-arm cone-beam CT: applications in the interventional suite. J Vasc Intervent Radiol 2008;19(6):799–813.
12. Brisco J, Fuller K, Lee N, et al. Cone beam computed tomography for imaging orbital trauma—image quality and radiation dose compared with conventional multislice computed tomography. Br J Oral Maxillofac Surg 2014;52(1):76–80.
13.. Tsao K, Cheng A, Goss A, Donovan D. The use of cone beam computed tomography in the postoperative assessment of orbital wall fracture reconstruction. J Craniofac Surg 2014;25(4):1150–4.
14. Sarkar S, Baliga M, Prince J, et al. Morphometric and volumetric measurements of orbit with cone-beam computed tomography. J Oral Maxillofac Surg 2021;79(3):652–64.
15. Fontolliet M, Bornstein MM, von Arx T. Characteristics and dimensions of the infraorbital canal: a radiographic analysis using cone beam computed tomography (CBCT). Surg Radiol Anat 2019;41(2): 169–79.
16. Raz E, Shapiro M, Shepherd TM, et al. Central retinal artery visualization with cone-beam CT angiography. Radiology 2021;302(2):419–24.
17. Esquivel A, Ferrero A, Mileto A, et al. Photon-counting detector CT: key points radiologists should know. Korean J Radiol 2022;23(9):854–65.
18. Benson JC, Campeau NG, Diehn FE, et al. Photon-counting CT in the head and neck: current applications and future prospects. Am J Neuroradiol 2024; 45(8):1000.
19. Farnsworth PJ, Campeau NG, Diehn FE, et al. High-resolution computed tomography angiography of the orbit using a photon-counting computed tomography scanner. Intervent Neuroradiol 20231591019923117519 8. https://doi.org/10.1177/15910199231175198.
20. Damadian R, Goldsmith M, Minkoff L. NMR in cancer: XVI. FONAR image of the live human body. Physiol Chem Phys 1977;9(1):97–100.
21. Haradome K, Haradome H, Usui Y, et al. Orbital lymphoproliferative disorders (OLPDs): Value of MR imaging for differentiating orbital lymphoma from benign OPLDs. Am J Neuroradiol 2014;35-(10):1976.
22. Eissa L, Abdel Razek AAK, Helmy E. Arterial spin labeling and diffusion-weighted MR imaging: utility in differentiating idiopathic orbital inflammatory pseudotumor from orbital lymphoma. Clin Imaging 2021;71:63–8.
23. He M, Cestari D, Cunnane MB, et al. The use of diffusion MRI in ischemic optic neuropathy and optic neuritis. Semin Ophthalmol 2010;25(5–6):225–32.

24. Bender B, Heine C, Danz S, et al. Diffusion restriction of the optic nerve in patients with acute visual deficit. J Magn Reson Imag 2014;40(2):334–40.
25. Tanenbaum RE, Lobo R, Kahana A, et al. Advances in magnetic resonance imaging of orbital disease. Can J Ophthalmol 2022;57(4):217–27.
26. Pollock JM, Tan H, Kraft RA, et al. Arterial spin-labeled MR perfusion imaging: clinical applications. Magn Reson Imaging Clin N Am 2009;17(2):315–38.
27. Xu XQ, Qian W, Ma G, et al. Combined diffusion-weighted imaging and dynamic contrast-enhanced MRI for differentiating radiologically indeterminate malignant from benign orbital masses. Clin Radiol 2017;72(10):903.e9-e15.
28. Ro SR, Asbach P, Siebert E, et al. Characterization of orbital masses by multiparametric MRI. Eur J Radiol 2016;85(2):324–36.
29. Yuan Y, Kuai XP, Chen XS, et al. Assessment of dynamic contrast-enhanced magnetic resonance imaging in the differentiation of malignant from benign orbital masses. Eur J Radiol 2013;82(9):1506–11.
30. Sun B, Song L, Wang X, et al. Lymphoma and inflammation in the orbit: diagnostic performance with diffusion-weighted imaging and dynamic contrast-enhanced MRI. J Magn Reson Imag 2017;45(5): 1438–45.
31. O'Shaughnessy E, Cossec C Le, Mambour N, et al. Diagnostic performance of dynamic contrast-enhanced 3T MR imaging for characterization of orbital lesions: validation in a large prospective study. Am J Neuroradiol 2024;45(3):342.
32. Jost SC, Ackerman JW, Garbow JR, et al. Diffusion-weighted and dynamic contrast-enhanced imaging as markers of clinical behavior in children with optic pathway glioma. Pediatr Radiol 2008;38(12):1293–9.
33. Russo C, Strianese D, Perrotta M, et al. Multi-parametric magnetic resonance imaging characterization of orbital lesions: a triple blind study. Semin Ophthalmol 2020;35(2):95–102.
34.. Nagesh CP, Rao R, Hiremath SB, Honavar SG. Magnetic resonance imaging of the orbit, part 1: basic principles and radiological approach. Indian J Ophthalmol 2021;69(10):2574–84.
35. Long NM, Smith CS. Causes and imaging features of false positives and false negatives on 18F-PET/CT in oncologic imaging. Insights Imaging 2011; 2(6):679–98.
36. Kalemaki SM, Karantanas HA, Exarchos D, et al. PET/CT and PET/MRI in ophthalmic oncology. Int J Oncol 2020;56(2):417–29 (Review).
37. Bastawrous S, Bhargava P, Behnia F, et al. Newer PET application with an old tracer: role of 18F-NaF skeletal PET/CT in oncologic practice. Radiographics 2014;34(5):1295–316.
38. Hofman MS, Lau WFE, Hicks RJ. Somatostatin receptor imaging with 68Ga DOTATATE PET/CT: clinical utility, normal patterns, pearls, and pitfalls in interpretation. Radiographics 2015;35(2):500–16.
39. Das S, Pineda G, Goff L, et al. The eye of the beholder: orbital metastases from midgut neuroendocrine tumors, a two institution experience. Cancer Imaging 2018;18(1):47.
40.. Al Feghali KA, Yeboa DN, Chasen B, et al. The use of ^{68}Ga-DOTATATE PET/CT in the non-invasive diagnosis of optic nerve sheath meningioma: a case report. Front Oncol 2018;8:454.