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Ex-PRESS glaucoma filter: an MRI compatible metallic orbital foreign body imaged at 1.5 and 3 T

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Abstract

AIM—To report on the MRI compatibility of the Ex-PRESS glaucoma filtration device, a tiny metallic implant placed into the anterior chamber of the eye that is much smaller than traditional glaucoma shunts, and to educate the radiology community regarding its appearance.

MATERIALS AND METHODS—Seven patients with Ex-PRESS glaucoma filtration devices were identified that had undergone MRI at San Francisco General Hospital/University of California San Francisco Medical Center by searching and cross-referencing the radiology reporting system and the electronic medical record. MRI images were reviewed for artefact interfering with interpretation. Ophthalmology examinations were reviewed for evidence of complications.

RESULTS—Eighteen individual MRI examinations were performed during 12 unique MRI events on these 7 patients. 13/18 individual MRI examinations and 7/12 MRI events were performed at 3 T with the others performed at 1.5 T. Mean time from Ex-PRESS implantation to MRI was 17.5 months. Mean time from MRI to first ophthalmology examination was 1.1 months and from MRI to latest ophthalmology examination was 6.6 months. Susceptibility artefact did not interfere with image interpretation and no complications related to MRI were encountered.

CONCLUSION—The Ex-PRESS glaucoma filtration device appears to be safe for MRI at 1.5 and 3 T and does not produce significant susceptibility artefact to affect diagnostic interpretation adversely.

Introduction

Glaucoma is a common chronic condition characterized by elevated intraocular pressure.¹ The mainstay of treatment is pharmacological, but surgery may be indicated for refractory cases.² Surgical procedures include drainage with glaucoma shunts/valves and trabeculectomy to improve egress of aqueous humour from the anterior chamber of the eye.^{3,4} The Ex-PRESS (excessive pressure regulating shunt system) glaucoma filtration device (Alcon Laboratories, Ft. Worth, TX, USA) is an alternative to traditional trabeculectomy.⁵ This small (approximately 3 mm in length) metallic implant (Fig. 1) is inserted into the anterior chamber at the limbus under a small conjunctival or scleral flap (Fig. 2) and provides drainage of aqueous humour into the subconjunctiva (Fig. 3).⁶

These implants are easily identified at CT as small metallic density orbital foreign bodies but may not be familiar to radiologists and may be interpreted as a contraindication to MRI. A prospective index case was encountered when a 65-year-old woman patient presented to the emergency room with vertigo and underwent an unenhanced CT examination of the head, which demonstrated a small, round, high-density foreign body located along the anteromedial aspect of the surface of each globe (Fig. 4). The presence of metallic foreign bodies associated with the globes was reported to the emergency room as a potential contraindication to a planned MRI. The two metallic foreign bodies were identified as Ex-PRESS glaucoma filtration devices through review of the patient's medical record and discussion with ophthalmology. The neuroradiology section was unfamiliar with the MRI safety of this metallic orbital implant. Investigation of the literature yielded no information in the radiology literature. A few papers from the ophthalmology literature were identified, which suggested MRI compatibility up to 1.5 T.⁷⁻⁹ The MRI was approved and performed under close supervision at 1.5 T. The patient tolerated the MRI examination without ill effect or complication, and subsequent slit lamp examination in the ophthalmology clinic revealed no evidence of dislocation of the shunts or other side effects related to imaging.

The aim of the present investigation was to establish the MRI compatibility of the Ex-PRESS glaucoma filtration device and to educate the radiology community regarding this device and its appearance on imaging. The hypothesis was that the Ex-PRESS glaucoma filtration device is MRI compatible at 1.5 and 3 T and that multiple MRI examinations had been performed without complication. Knowledge of the existence of, appearance of, and MRI compatibility of these devices by radiologists can help facilitate MRI of these patients when necessary.

Materials and methods

Following the prospectively identified index case, an institutional review board and health insurance portability and accountability act (HIPAA)-compliant retrospective cohort study was initiated to identify MRI examinations performed on patients with Ex-PRESS glaucoma filtration devices and document MRI compatibility. Two methods were used to identify cases: first, a search was performed through the radiology reporting system (1999–2014) for MRI reports with a mention of the word “glaucoma” and the imaging report, imaging study, and medical record were reviewed to determine whether the case met inclusion/exclusion

criteria. Three cases were identified in this manner. Second, a search was performed through the electronic medical record billing system for the current procedural terminology (CPT) codes 66180 and 0192T to identify all cases of glaucoma shunts (Ex-PRESS or long-tube shunts) placed at San Francisco General Hospital in 2013 and 2014 ($n = 162$) and the cases were cross-referenced against the electronic medical records to determine cases that met inclusion/exclusion criteria. Three additional cases were identified in this manner. Inclusion criteria were an implanted Ex-PRESS glaucoma filtration device and a subsequent MRI performed at San Francisco General Hospital while the shunt was in place. Exclusion criteria were absence of the Ex-PRESS glaucoma filtration device, a glaucoma implant that was not an Ex-PRESS without an Ex-PRESS present, and an MRI that was performed before the Ex-PRESS was present.

The electronic medical record was reviewed to determine the age at the time of first MRI following the Ex-PRESS implantation, laterality of the implant, and the gender of each patient. Mean, range, and standard deviation of age in years were calculated. The imaging study was reviewed to determine the type(s) and number of MRI examinations performed at each MRI event (unique date/trip to MRI), the field strength, and the presence of any artefact that significantly affected image interpretation for the given clinical indication. The electronic medical record was reviewed for any evidence of immediate or delayed complication related to MRI. Specifically the MRI report/visit notes and all subsequent ophthalmology clinical notes were reviewed for mention of complication related to the MRI and/or dislocation of the Ex-PRESS glaucoma filtration device. The date of the Ex-PRESS implantation surgery and the date of each MRI event were used to calculate the time to each MRI event and time to first MRI event in months. The date of ophthalmology examinations and MRI events were used to calculate the time in months from each MRI event to the first subsequent ophthalmology examination, from each MRI event to the latest ophthalmology examination, and from the first MRI event to the latest ophthalmology examination for each patient. Means and standard deviations were calculated for time to each MRI event, time to first MRI event, time from each MRI event to the first ophthalmology examination, time from each MRI event to the latest ophthalmology examination, and time from first MRI event to the latest ophthalmology examination.

Results

Results are summarized in Table 1. Seven patients with Ex-PRESS glaucoma filtration devices who had undergone a subsequent MRI examination at San Francisco General Hospital were identified. Mean patient age at first MRI was 73 years with a standard deviation of 11.2 years and a range of 61–88 years. Five patients were female and two patients were male. These seven patients had a total of eight Ex-PRESS glaucoma filtration devices (one bilateral, four left, and two right). Twelve unique MRI events with 18 individual MRI examinations were performed (seven head/brain MRI examinations, one neck dynamic MR angiogram, two cervical spine MRI examinations, three thoracic spine MRI examinations, four lumbar spine MRI examinations, and one pelvis MRI). Seven out of 12 MRI events and 13/18 individual MRI examinations were performed at 3 T with the others performed at 1.5 T.

Six of seven patients had their Ex-PRESS implantation performed at San Francisco General Hospital, and thus the date of implantation was available. For these six patients, the mean time from Ex-PRESS implantation to the unique MRI event was 17.5 months (SD = 9.8 months, range 3–32 months) and the mean time from Ex-PRESS implantation to the first MRI event was 14.2 months (SD = 10.5 months, range 3–32 months).

Five of seven patients had documented ophthalmology examinations following their MRI. For these five patients, the mean time from each unique MRI event to the first subsequent ophthalmology examination was 1.1 months (SD = 0.8 months, range 0.25–2 months) and to the latest ophthalmology examination was 6.6 months (SD = 3.3 months, range 2–11 months), and the mean time from the earliest MRI event to the latest ophthalmology examination was 7.2 months (SD = 3.6 months, range 3–11 months). None of the ophthalmology examinations following MRI demonstrated evidence of dislocation of the Ex-PRESS device or other side effect related to imaging. The MRI images were of good quality with only minimal susceptibility artefact on the seven studies where the device was included in the field of view. In none of the cases did the artefact associated with the device interfere with image interpretation.

Discussion

The Ex-PRESS glaucoma filtration device is a small stainless steel implant that is readily apparent at CT as a metallic foreign body associated with the anterior globe. Screening for and identification of any metallic foreign bodies near the globe is an important part of MRI safety, and thus, it is prudent to consider the safety aspects of MRI in patients with these devices. As radiologists, the present authors were unfamiliar with this particular device prior to encountering the index patient but needed to investigate the safety of MRI prior to approving the study. The present study documented 18 individual MRI examinations performed at both 1.5 and 3 T in seven patients with Ex-PRESS glaucoma filtration devices without complication and only minimal artefact that did not affect imaging interpretation. The Ex-PRESS glaucoma filtration device can be considered MRI compatible at 1.5 and 3 T; knowledge of the imaging appearance and MRI compatibility of this device by radiologists could help facilitate MRI in these patients when necessary.

There is relatively little literature regarding the safety of MRI with the Ex-PRESS glaucoma filtration device, but what literature exists suggests that it is safe at 1.5 T. *Ex-vivo* tests have demonstrated that although the Ex-PRESS device is made of 316L stainless steel, it does exhibit ferromagnetic properties. Seibold *et al.*⁷ demonstrated significant displacement of the device during a torque test at 4.7 T, but no displacement during torque tests at 1.5 or 3 T. They also demonstrated angular displacement during pendulum style translational force tests at 1.5, 3, and 4.7 T, which increased with increasing field strength. No significant heating of the device was observed in that study during typical brain MRI conditions. Geffen *et al.*⁸ demonstrated immediate movement of the device across a wet petri dish at both 1.5 and 3 T, but no movement of the device when placed on a dry petri dish at both 1.5 and 3 T. They went on to test the device when placed into the anterior chamber of a human cadaver eye (intracameral test) and when implanted through the sclera (scleral fixation test) with no movement detected at 3 T. De Feo *et al.*⁹ published a series of five patients with a total of

seven implants who underwent MRI at 1.5 T without adverse event or artefact affecting interpretation of brain MRI but some degree of artefact in the region of the optic nerve. Consistent with De Feo *et al.*, susceptibility artefact related to the orbital implants in the present cases did not significantly obscure visualization of the brain, optic nerves, or posterior globes with conventional T1- and T2-weighted spin echo sequences at 1.5 T (Fig. 4). Even with single-shot echo planar diffusion-weighted and susceptibility-weighted sequences, which are particularly sensitive to paramagnetic susceptibility artefact, no significant degradation of image quality was noted (Fig. 5). The current manufacturer's recommendations are that MRI of the head is permitted, but not recommended within the first 2 weeks post-implantation (http://ecatalog.alcon.com/PI/ExPress_us_en.pdf).

The Ex-PRESS glaucoma filtration device appears more similar to an orbital foreign body, which might contraindicate MRI, on CT than a traditional glaucoma shunt and is likely an unfamiliar device to most radiologists. The more traditional long tube glaucoma shunt has a large associated plate that is implanted in a sub-scleral pocket and develops an associated filtration bleb (Fig. 6).¹⁰ The much smaller Ex-PRESS glaucoma filtration device does not have the associated large sub-scleral plate, making recognition more difficult. Confusion with an MRI incompatible metallic foreign body could be particularly troublesome when unilateral or without adequate medical history; thus recognition of this MRI compatible device by the radiologist is important.

The present study was limited by the retrospective technique and small sample size. Following the index case that initiated this study, it was likely that multiple patients had already been imaged with Ex-PRESS glaucoma filtration devices that were unknown/not revealed to radiology and thus the present study was undertaken to investigate whether the Ex-PRESS device was compatible with MRI at 1.5 and 3 T. Ideally, all patients would have full ophthalmology follow-up; however, this was only available for five of the seven patients. For the ophthalmology examinations performed in follow-up, the ophthalmologist may have been, but was not necessarily, aware that the patient had undergone an MRI and therefore to look for related complications. In some ways, this may have prevented the recall bias of attributing any abnormality present to the MRI. Similarly, the patients and the radiologists approving the studies were likely not aware that the MRI was being performed in the presence of a device with ferromagnetic properties and little research documenting its safety in patients at 1.5 T and no research documenting its safety in patients at 3 T. The present study, despite its findings of MRI compatibility, highlights the importance of full disclosure and investigation of medical devices and implants prior to MRI and that small and unfamiliar devices may be overlooked by both the patient and medical staff.

In conclusion, 18 individual MRI examinations performed at both 1.5 and 3 T in seven patients with the Ex-PRESS glaucoma filtration device were reported. The Ex-PRESS glaucoma filtration device is gaining popularity as a surgical treatment for refractory glaucoma, and it is likely that more patients with these devices will be referred for CT and MRI in the future.⁴ As technology advances and novel surgical implants become more ubiquitous and smaller, it is prudent to consider and document the MRI safety and compatibility of these devices. This device, despite exhibiting ferromagnetic properties,

appears to be safe for MRI at 1.5 and 3 T, and does not produce significant susceptibility artefact to adversely affect diagnostic interpretation of routine brain MRI.

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Highlights

- The Ex-PRESS glaucoma filtration device is a tiny metallic orbital implant.
- It can simulate a metallic orbital foreign body on imaging.
- There is little information in the literature about it's MRI safety.
- We report 18 MRIs performed on 7 patients including the first at 3 T.
- Imaging appears to be safe at 1.5 and 3 T in patients with this device.



Figure 1. The Ex-PRESS glaucoma filtration device (Alcon Laboratories) placed on a penny for reference. This device is approximately 3 mm in length. For reference a penny is 19.05 mm in diameter (United States Mint). Photo by S.C.L.

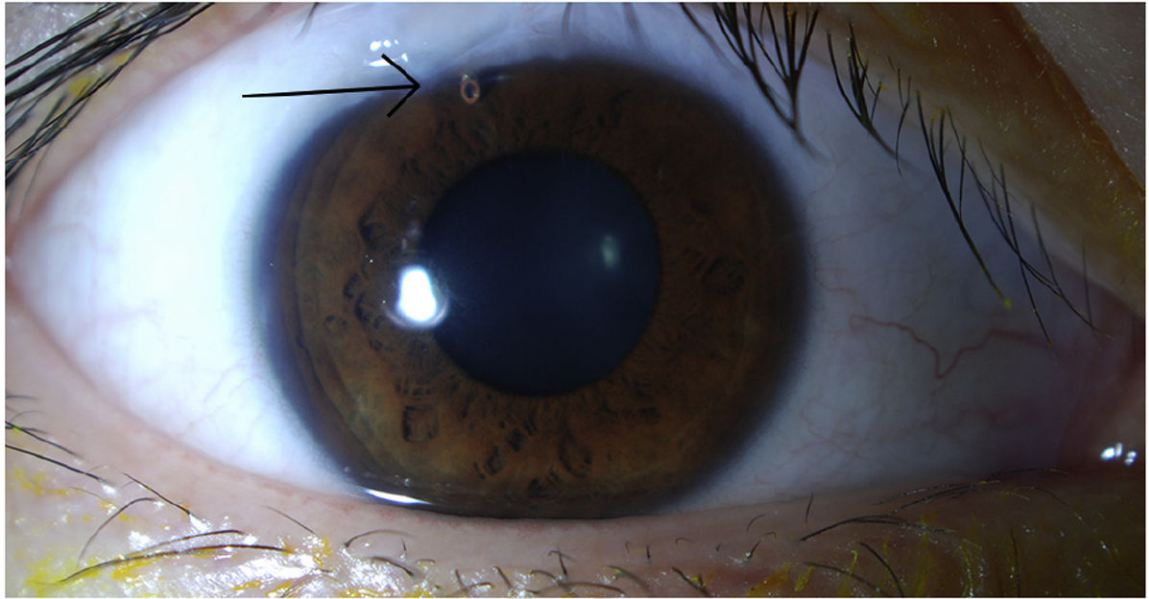


Figure 2.

An example of the Ex-PRESS glaucoma filtration device (Alcon Laboratories) within a patient's eye (arrow). This device is inserted into the anterior chamber at the limbus under a small conjunctival or scleral flap and provides drainage of aqueous humour into the subconjunctiva. Photo by S.C.L.

Glaucoma drainage devices

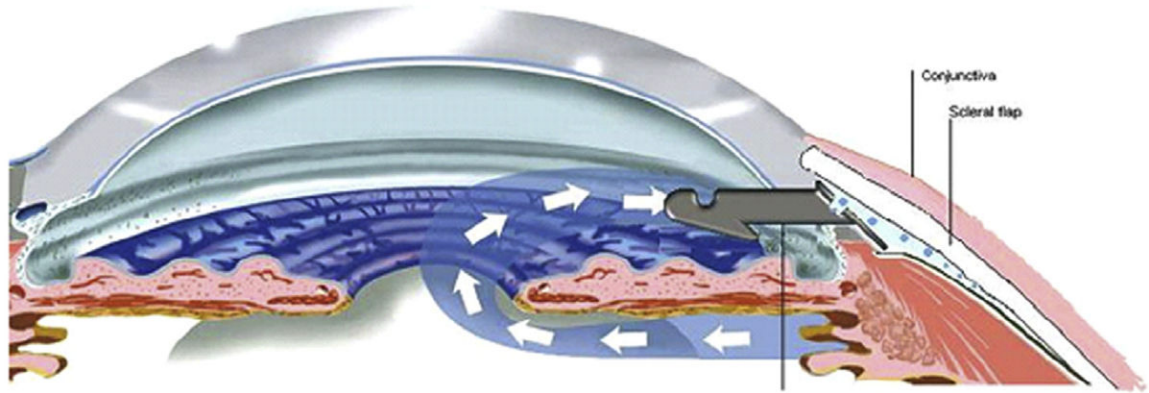


Figure 3.

Diagram showing the method of action of the Ex-PRESS glaucoma filtration device. Original figure from De Feo et al., *Am J Ophthalmol.*⁹ Reprinted with permission from Elsevier Copyright Clearance Center.

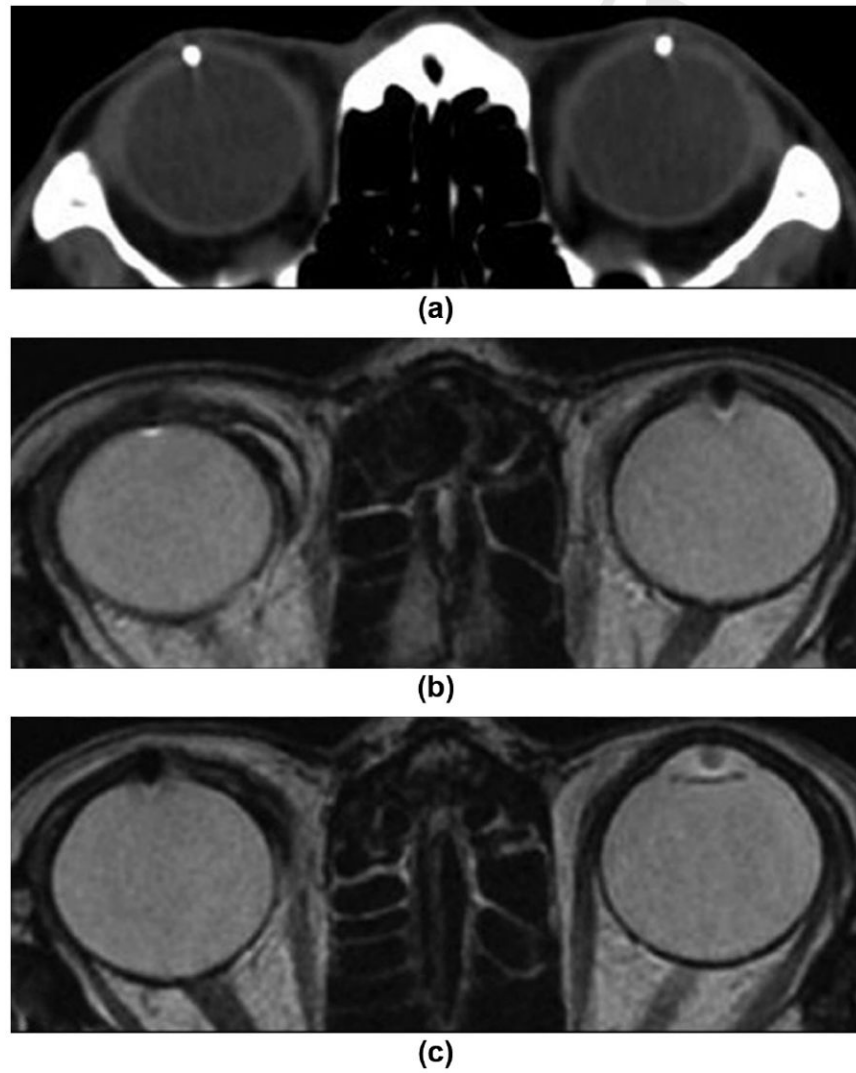


Figure 4.
(a) Non-contrast axial CT image showing the high-attenuation implants within the surface of the globes along the anterior chamber. A small amount of metallic streak artefact is present.
(b–c) Contiguous axial T2-weighted MRI images at 1.5 T demonstrating a small amount of magnetic susceptibility artefact associated with the implants.

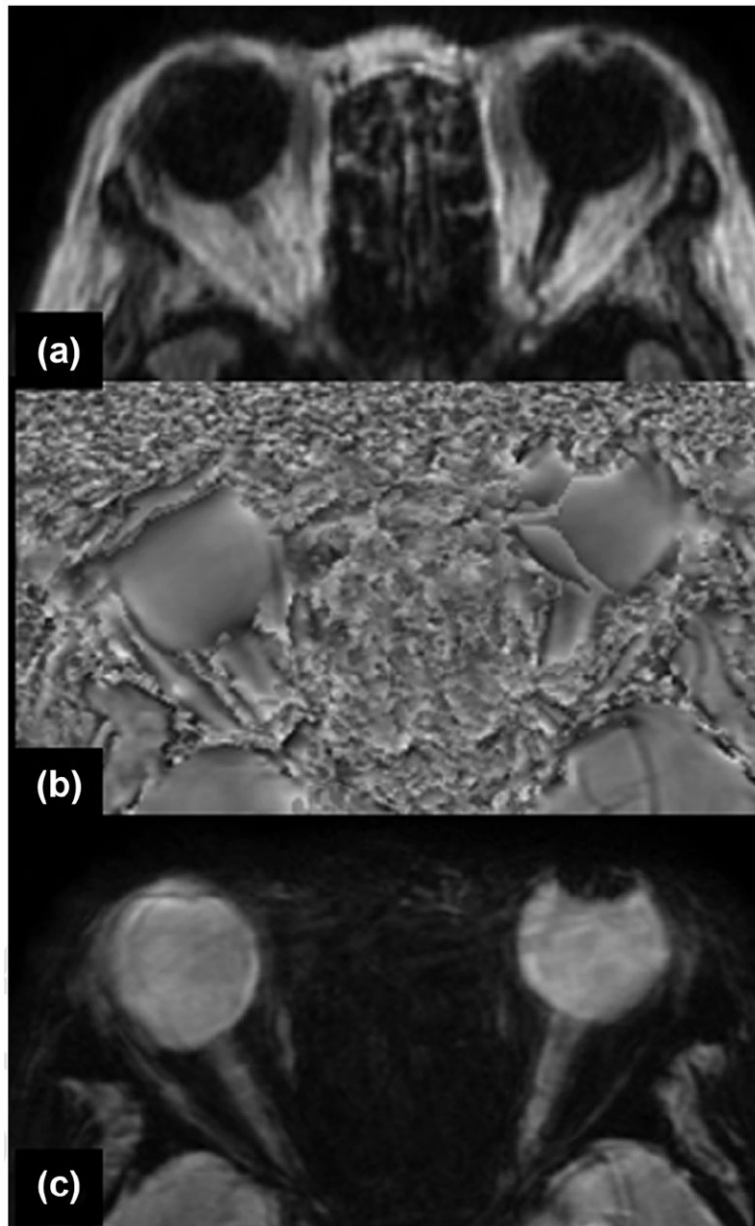


Figure 5. Left-sided Ex-PRESS glaucoma filtration device in a patient imaged at 3 T. Note the minimal susceptibility artefact with conventional fast spin-echo technique on this axial T2 fluid attenuated inversion recovery (FLAIR) image (a). Even with susceptibility-weighted sequences, minimal local phase dispersion and signal loss is seen in the region of the device on the phase map (b) and susceptibility-weighted image.

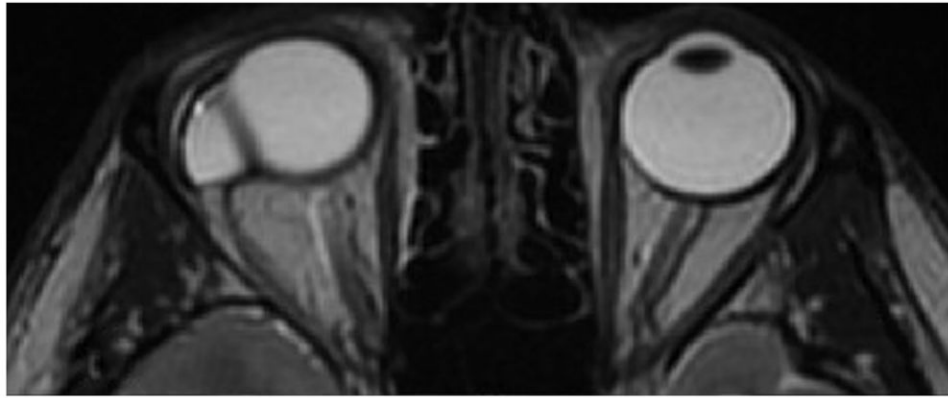
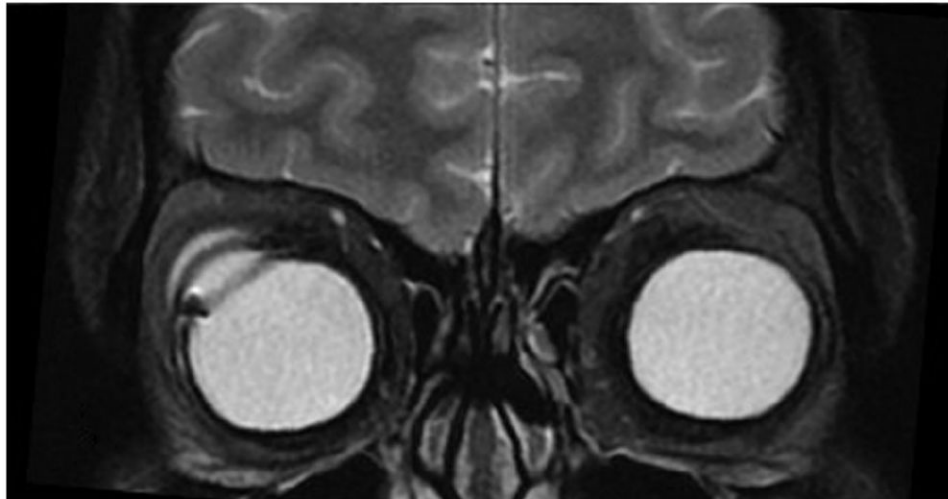
**(a)****(b)**

Figure 6. Traditional larger glaucoma tube shunt on (a) axial and (b) coronal T2-weighted MRI images. Note the large sub-scleral implanted plate along the superior-lateral globe and associated overlying sub-scleral bleb.

Table 1

Patient characteristics and MRI examinations.

Age at first MRI (years)	Gender	Laterality of Ex-PRESS	MRI event	Field strength (T)	Individual MRI examinations	Months from OR to MRI	Months to first eye examination	Months to latest eye examination
65	Female	Bilateral	1	1.5	Brain	17	2	4
62	Female	Left	1	1.5	Pelvis	32	NA	NA
81	Female	Left	2	1.5	Brain	32	NA	NA
			1	3	Brain and neck	NA	NA	NA
			2	3	MRA(2)	NA	NA	NA
			1	3	C/T/L spine ³	NA	NA	NA
70	Male	Left	1	3	T/L spine ²	17	2	8
			2	3	L spine	17	2	8
			3	3	T/L spine ²	18	1	7
			4	1.5	Brain	23	0.5	2
88	Female	Left	1	3	Brain	3	0.5	11
84	Male	Right	2	1.5	Brain	11	0.25	3
61	Female	Right	3	3	Brain and C spine ²	5	0.5	10
Mean 73	5:2	1 Bilateral	12	7at 3 T	18 Examinations	Mean 17.5	Mean 1.1	Mean 6.6
SD 11.2	Female:	4 Left	Total	5 at 1.5 T		SD 9.8	SD 0.8	SD 3.3
	Male:	2 Right						

No immediate or delayed complications were noted on ophthalmological examination.

SD=Standard Deviation. C Spine=Cervical Spine. T Spine=Thoracic Spine. L Spine=Lumbar Spine. MRA=MR Angiogram. T=Tesla. OR=Operating Room. Ex-PRESS (excessive pressure regulating shunt system).