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Case report

Undetected intraocular metallic foreign body causing hyphema in a patient undergoing MRI: a rare occurrence demonstrating the limitations of pre-MRI safety screening

David A. Lawrence [a], Adam T. Lipman [b], Sumeet K. Gupta [c], Nicholas C. Nacey [d,*]

[a] Department of Diagnostic Radiology and Medical Imaging, University of Virginia School of Medicine, Charlottesville, VA
[b] Department of Ophthalmology, University of Virginia School of Medicine, Charlottesville, VA
[c] University of Virginia School of Medicine, Charlottesville, VA
[d] Department of Diagnostic Radiology and Medical Imaging, University of Virginia School of Medicine, Charlottesville, VA

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ABSTRACT

The case reported is of a 47-year-old man with an undetected ferromagnetic metallic intraocular foreign body in the right eye who underwent elective MR examinations for chronic neck and low back pain. The patient underwent the MR scans and subsequently developed blurred vision in his right eye caused by a hyphema associated with an anterior chamber metallic foreign body. Case reports of orbital injuries in patients with intraocular metallic foreign bodies undergoing MRI are rare, with only one prior report in the radiology literature. While the incidence of intraocular foreign bodies causing injury in patients undergoing MRI is likely rare even among patients with foreign bodies, this case demonstrates that complications from an IMFB can potentially have a subtle presentation. Our case also illustrates potential limitations of pre-MRI safety questionnaires, particularly pertaining to a patient's understanding of the thoroughness of foreign body removal.

1. Introduction

Since the initial report by Kelly et al. in 1986 of an adverse event in a patient with an intraorbital metallic foreign body (IMFB), no additional case reports of orbital adverse events have been reported in the radiology literature [1]. In the non-radiology English literature, there have been only two additional reported cases of adverse events associated with MRI of patients with IMFBs, both of which were in ophthalmology journals [2,3]. Screening for metallic foreign bodies in the orbit via patient questionnaires and orbital radiographs has been commonplace in radiology departments since the 1980s, despite the limited case reports of adverse events.

In Kelly et al.'s seminal case report in 1986, a 63-year-old former sheet metal worker who was recently diagnosed with adenocarcinoma underwent a brain MR prior to whole brain radiation therapy treatment. As he was removed from the 0.35 T magnet bore, the patient experienced left eye pain, a flash of light, and then loss of vision in his left eye. Examination revealed vitreous hemorrhage, and subsequent CT of the orbits demonstrated an IMFB [1].

In the case report from Ta et al., a 63-year-old man who was a former metal worker who had undergone heart transplant in the last year presented with fever, headaches, and altered mental status. A brain MRI was obtained. Immediately after the study the patient reported sudden left eye pain and loss of vision. Examination revealed a small paracentral corneal scar and a 50% hyphema without vitreous hemorrhage. Subsequent CT scan demonstrated an IMFB [2]. In Vote et al.'s case report, a 31-year-old man underwent a brachial plexus MRI when a small IMFB was missed on screening radiographs. The patient did not have any immediate complications; however, he developed a rapidly progressing cataract, which was subsequently successfully treated [3].

We present a case of a 47-year-old man who underwent an elective cervical and lumbar spine MRI for chronic neck and back pain who developed blurred vision and microhyphema in his right eye associated with a 1–2 mm IMFB embedded within the iris. A safety questionnaire performed before the MRI scan failed to arouse adequate suspicion among radiology staff for an orbital metallic foreign body, and consequently orbital radiographs were not performed.

2. Case report

A 47-year-old male presented to an outpatient imaging center for cervical and lumbar spine MRIs to evaluate his chronic neck and

* Corresponding author at: Department of Radiology and Medical Imaging, Box 800170, University of Virginia Health System, Charlottesville, VA 22908. Tel.:+1 434 982 0428; fax: +1 434 924 8698.
E-mail address: NCN5T@hscmail.mcc.virginia.edu (N.C. Nacey).

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lower back pain. These were the first imaging examinations performed at our institution. As is our protocol with all patients, the patient filled out an MRI safety questionnaire. He answered that he previously had metal in his right eye following multiple traumatic events. The MRI nurse and technologist then interviewed the patient, who stated that the metal had been removed during a visit to the emergency room at an outside hospital. Additionally, the patient told the technologist and nurse that he had successfully undergone MRIs since that time. Radiology support staff judged that it was safe for the patient to undergo the MRI, and no physician was notified at the time.

A Siemens Magnetom Espree 1.5 T with an open bore design and gradient strength of 33 mT/m was utilized for the exam. The total imaging time was approximately 41 minutes, and the patient tolerated the exam without immediate incident. However, approximately 45 minutes after leaving the outpatient facility, he returned to the front desk of the facility complaining of blurred vision in his right eye. The nurse told the patient that he could visit his primary care physician or go to the emergency department, particularly if his symptoms did not improve by the next morning.

The next morning, a registered nurse called the patient to check the status of his vision. The patient complained of unchanged right eye blurred vision, but no eye pain. The nurse then called the radiologists to determine what should be done. The radiologist contacted the patient directly by telephone. Upon further questioning, the patient admitted that he had multiple occasions where metal penetrated his globe while metalworking. He had been treated at an outside emergency department on those occasions, and he stated that some orbital metal had been removed. However, he was now unsure if all of the metal had been removed. He also stated that while he believed he had undergone prior MRI exams at an outside institution, he was now unsure if these exams were done before or after the multiple traumatic incidents to his globe. The patient was strongly advised to go to the emergency department to be evaluated by an ophthalmologist, as it was unclear whether there was a metallic foreign body in the orbit as well as whether there had been any damage to the patient's globe.

After presenting to the emergency room, ophthalmology was consulted. Slit lamp examination revealed a healed 3.5 mm full thickness linear corneal stromal scar, suggesting a history of a previous perforating eye injury (Fig. 1). On gonioscopic examination, a small metallic fragment was identified in the peripheral aspect of the iris underlying an area of focal blood clot in the inferior angle of the anterior chamber (Fig. 2). There was a small focal cataract in this area. On dilated fundoscopic examination, there was no evidence of involvement of the posterior segment of the eye. B-scan ultrasound demonstrated shadowing from the small metallic foreign body (Fig. 3).

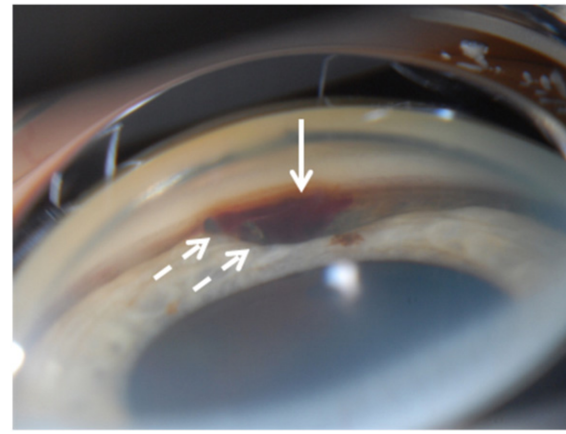

Fig. 2. Initial slit lamp gonioscopic examination 1 day after the MR scan viewing the inferior angle of the anterior chamber (looking superior to inferior as if a bird's eye view) demonstrating focal hyphema (solid arrow) and the edges of a bilobed metallic fragment appearing at the temporal aspect (dashed arrows).

By the time of his 15 day follow-up examination, the patient's vision had returned to normal, and his anterior chamber was clear with resolution of the clotted blood in his inferior angle (Fig. 4). The metallic foreign body was securely embedded in the iris stroma in an area with fibrotic changes and angle recession, suggesting that this was the original location of the object prior to his MRI examination. The patient along with the ophthalmologists decided to manage his case nonsurgically with close observation for the development of recurrent hyphema, angle recession glaucoma, worsening cataract, or siderosis. It was also agreed that the patient should continue to have regular eye examinations, disclose this past injury at medical examinations with new practitioners, and avoid MRI studies in the future.

3. Discussion

An IMFB in patients undergoing MRI scanning is a common problem faced by radiologists on a near daily basis, even though there have been limited case reports of patients suffering from adverse events. The incidence of IMFBs in the general population has been previously reported at 0.27%, and is also relatively low in at-risk populations of patients with a history of metalworking or prior orbital trauma with metal, with an incidence of 2.5% [4].

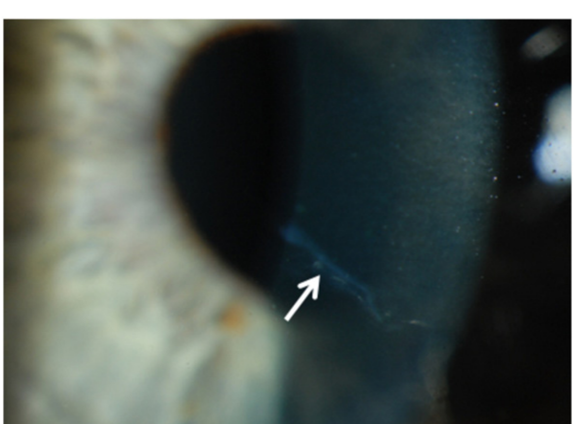

Fig. 1. Slit lamp image demonstrating a linear corneal scar, which provides evidence of a previous penetrating eye injury (solid arrow).

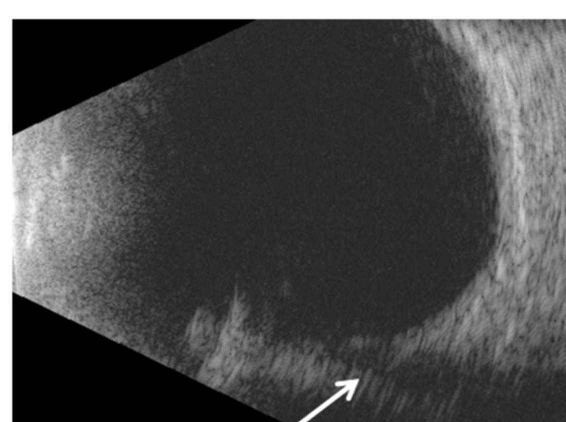

Fig. 3. B-mode ultrasound reveals shadowing caused by the metallic fragment (solid arrow). The metallic fragment is difficult to visualize, presumably due to its small size.

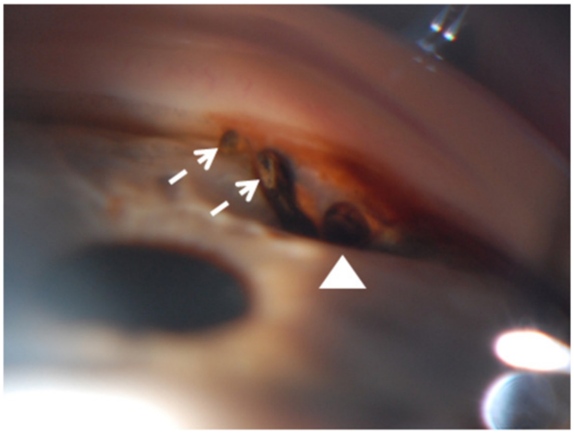

Fig. 4. Follow-up slit lamp gonioscopic exam 16 days after the MR scan demonstrates resolution of the focal hyphema with improved visualization of the metallic fragment embedded in the iris stroma and ciliary body within an area of posttraumatic angle recession (dashed arrows). There is also a small defect in the iris at the site of prior perforation, with visualization of the dark ciliary body deep to the iris through the defect (arrowhead).

After the initial case report by Kelly et al., there were several studies performed to determine the effect of MRI on IMFBs, both in vivo and in vitro [4–8]. Some of the early studies were performed at low field strength, including a study by Kelsey et al. that was performed at 0.06 T, in which the authors implanted ferromagnetic fragments from 0.25 to 2.2 mm in the vitreous humor of explanted bovine and leporine eyes and determined that the fragments did not significantly move [6]. Other studies performed at a magnetic field strength of 1.5 T did demonstrate motion of metallic fragment when subjected to the magnetic field [7]. The initial report of monocular blindness following MRI reported by Kelly et al. in 1986 occurred during exam with a 0.35 T magnet [1]. Given that most current MRI scanning is currently performed at 1.5 T, and 3 T imaging is now commonplace as well, it is conceivable that more adverse events may occur at these higher field strengths than have occurred in the past.

Multiple factors have to align for a patient to sustain orbital damage from an IMFB. The metal must be ferromagnetic, the most common of which are iron, nickel, and cobalt. The shape of the object likely contributes to the risk for injury, as a sharp metallic object would be expected to incite more damage than a round object. The degree to which the IMFB is imbedded within surrounding tissues may play a role if its movement is inhibited. Furthermore, the IMFB must undergo sufficient torque (rotational motion) or force (translational motion) to induce injury, factors which are variable based on the magnetic field and the orientation of an object within the magnetic field. Torque is most significant with nonspherical objects that are orthogonal to the B0 magnetic field and are in the center portion of the magnetic field strength that is the strongest [9], but is likely of less concern than force for small objects such as in this case. In contrast to torque, force is more significant for objects that are aligned with the B0 magnetic field. More importantly, force is greatest near the edge of the magnetic bore [9]; therefore an object is at great risk for moving when the patient is getting into the magnet, getting out of the magnetic, or during scanning when the IMFB is closer to the edge of bore. The latter scenario may have played a role for our patient when the lumbar spine was being scanned, placing the IMFB near the edge of the magnetic bore.

Undoubtedly, patients have been scanned since the beginnings of MRI usage in the 1980s who had an IMFB. As of 1994, it was reported that 5% of institutions had no screening protocol in place for orbital metal fragments, with an estimated 2,400 patients with IMFBs that may have been scanned between 1986 and 1994 [4]. In addition to centers that do not screen patients pre-MRI, breakdowns in screening protocols likely happen on occasion, resulting in patients with IMFBs being scanned by MRI [10]. Given the minimal number of case reports of IMFBs causing injury after MRI, there are likely many cases where these patients are scanned without incident.

Orbital radiographs are the most common imaging modality employed to assess for IMFBs [11]. However, there have been case reports of patients undergoing MRI examinations with missed IMFBs, including Vote et al. describing a case of a 31-year-old man with a known metallic intraocular foreign body in the anterior lens capsule who underwent a brachial plexus MRI [3]. The metallic foreign body was not noted on the orbital radiographs in that case, and the patient underwent the MRI [3]. Orbital radiographs were not performed in our case. However, given the 1–2 mm size of the metallic fragment on ophthalmological exam, its anterior chamber location where overlapping bone would not be expected, and its visibility on B-mode ultrasound, it is probable that the metallic fragment would have been visualized had radiography been performed.

As a result of the initial case report by Kelly et al., numerous suggestions for pre-MRI screening have been released, including a white paper from the American College of Radiology (ACR) in 2002 [11–19]. Of note, the white paper from the ACR regarding MR safety recommends “All patients who have a history of orbit trauma by a potential ferromagnetic foreign body for which they sought medical attention are to have their orbits cleared by either plain x-ray orbit films (two views) or by a radiologist's review and assessment of contiguous cut prior CT or MR images (obtained since the suspected traumatic event) if possible [15].” While our patient did receive medical care after the original traumatic events to his globe, our case illustrates how patients may inaccurately remember details surrounding the initial trauma. As such, radiologists may want to ere on the side of caution and obtain additional screening if the patient's story is unclear. Limiting orbital screening radiographs to patients who sought prior medical attention could result in some IMFBs being missed.

The patient initially stated on the questionnaire that the IMFB had been removed and he had undergone subsequent MRIs, but these statements were subsequently less clear when following up with the patient after the MRI. While patients may be told that a foreign body has been removed, it is difficult to know if all of the metal has been removed, particularly if there is a component in the globe itself. Even if there is metal removed from the surface of the eye by an emergency department physician, often times there is no slit lamp available for further ophthalmologic examination, or emergency department staff may have limited experience performing a complete ocular examination. Penetrating scleral or corneal injuries resulting in an intraocular metallic foreign body can present with ophthalmologic findings that can be subtle even to an experienced ophthalmologist. Complicating matters, a patient may mistake an emergency department physician for an ophthalmologist simply because the physician examined the eye and flushed it with saline. Detailed questioning about the examination and follow-up care is necessary. As a general rule, any patient who gets metal in their eye should be referred to an ophthalmologist for examination following the injury. In our case, removal of a metallic fragment in the globe is unlikely to have occurred in the emergency department, as this requires ophthalmologic evaluation and likely a surgical procedure in an operating room. In their analysis of the cost utility of radiographic screening for metallic foreign bodies, Seidenwurm et al. advocate asking the patient if the doctor got all the metal out [18]. However, in our case this approach proved to be unreliable. In addition, patients may incorrectly remember the timing of radiology exams or may misunderstand what type of radiology exam took place. For example, patients may confuse a CT with an MRI exam, thus making a history of successful MRI exams since the traumatic event unreliable.

In conclusion, there are exceedingly few reported adverse events associated with MRI examinations, particularly regarding IMFBs. Nonetheless, as this case highlights, adverse events can occur despite appropriate screening protocols being in place. Morbidity can occur from globe injury without a presentation as dramatic as the monocular blindness seen in the initial Kelly et al. report. The subtle clinical presentation of our patient's blurred vision suggests that such symptoms may not immediately be recognized as caused by the recent MRI exam. We hope this case report heightens the awareness of physicians and non-physician healthcare providers to the potential dangers of MRI and increases their vigilance in appropriately screening patients.

References

[1] Kelly WM, Paglen PG, Pearson JA, San Diego AG, Soloman MA. Ferromagnetism of intraocular foreign body causes unilateral blindness after MR study. AJNR Am J Neuroradiol 1986;7:243–5.
[2] Ta CN, Bowman RW. Hyphema caused by a metallic intraocular foreign body during magnetic resonance imaging. Am J Ophthalmol 2000;129:533–4.
[3] Vote BJ, Simpson AJ. X-ray turns a blind eye to ferrous metal. Clin Experiment Ophthalmol 2001;29:262–4.
[4] Williamson MR, Espinosa MC, Boutin RD, Orrison Jr WW, Hart BL, Kelsey CA. Metallic foreign bodies in the orbits of patients undergoing MR imaging: prevalence and value of radiography and CT before MR. AJR Am J Roentgenol 1994;162:981–3.
[5] Cullen C, Kendall E, Cui J, Colleaux K, Grahn B. The effects of exposure to a 1.5-tesla magnetic field on intravitreous metallic foreign bodies in rabbits. Graefes Arch Clin Exp Ophthalmol 2002;240:393–402.
[6] Kelsey CA, King JN, Keck GM, Chiu MT, Wolfe DM, Orrison WW. Ocular hazard of metallic fragments during MR imaging at 0.06 T. Radiology 1991;180:282–3.
[7] Lagouros PA, Langer BG, Peyman GA, Mafee MF, Spigos DG, Grisolano J. Magnetic resonance imaging and intraocular foreign bodies. Arch Ophthalmol 1987;105:551–3.
[8] Williamson TH, Smith FW, Forrester JV. Magnetic resonance imaging of intraocular foreign bodies. Br J Ophthalmol 1989;73:555–8.
[9] Nyenhuis JA, Park Sung-Min, Kamondetdacha R, Amjad A, Shellock FG, Rezai AR. MRI and implanted medical devices: basic interactions with an emphasis on heating. IEEE Trans Device Mater Reliab 2005;5(3):467–80.
[10] Elmquist C, Shellock FG, Stoller D. Screening adolescents for metallic foreign bodies before MR procedures. J Magn Reson Imaging 1995;5:784–5.
[11] Bailey WR. L. Screening for intra-orbital metallic foreign bodies prior to MRI: review of the evidence. Radiography 2007;13:72–80.
[12] Bryden FM, Pyott AA, Bailey M, McGhee CN. Real time ultrasound in the assessment of intraocular foreign bodies. Eye 1990;4(Pt 5):727–31.
[13] Elster AD, Link KM, Carr JJ. Patient screening prior to MR imaging: a practical approach synthesized from protocols at 15 U.S. medical centers. AJR Am J Roentgenol 1994;162:195–9.
[14] Jarvik JG, Ramsey S. Radiographic screening for orbital foreign bodies prior to MR imaging: is it worth it? AJNR Am J Neuroradiol 2000;21:245–7.
[15] Kanal E, Borgstede JP, Barkovich AJ, et al. American College of Radiology White Paper on MR Safety. AJR Am J Roentgenol 2002;178:1335–47.
[16] Murphy KJ, Brunberg JA. Orbital plain films as a prerequisite for MR imaging: is a known history of injury a sufficient screening criterion? AJR Am J Roentgenol 1996;167:1053–5.
[17] Otto PM, Otto RA, Virapongse C, et al. Screening test for detection of metallic foreign objects in the orbit before magnetic resonance imaging. Invest Radiol 1992;27:308–11.
[18] Seidenwurm DJ, McDonnell III CH, Raghavan N, Breslau J. Cost utility analysis of radiographic screening for an orbital foreign body before MR imaging. AJNR Am J Neuroradiol 2000;21:426–33.
[19] Shellock FG, Crues JV. MR procedures: biologic effects, safety, and patient care. Radiology 2004;232:635–52.