Managing Magnets: An audit of introduction of the RCEM Best Practice Guideline (Title)

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Short title: Managing Magnets

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ABSTRACT

Aim: To evaluate management of children and young people presenting to the emergency department (ED) with magnet ingestion before and after new guidance.

Methods: In May 2021, a National Patient Safety Agency and Royal College of Emergency Medicine (RCEM) Best Practice Guideline about management of ingested magnets was published. This was implemented in our department. Children and young people presenting after magnet ingestion were identified from Snomed (coded routinely collected data) and x-ray requests between January 2016 – March 2022. Management was compared to national guidance.

Results: There were 138 patient episodes of magnet ingestion, with a rising incidence over the 5-year period. Following introduction of the guideline, there was a higher incidence of admission (36% vs 20%) and operative intervention (15.7% vs 8%). Use of follow-up x-ray increased from 56% to 90%. There was substantial variation in the management prior to guidance which reduced after introduction of the RCEM guidance.

Conclusion: Management of magnet ingestion has become more standardised since introduction of the National RCEM Best Practice Guideline, but there is still room for improvement.

Keywords

Foreign body
Ingestion
Magnet
Rare-earth
Super-strong

Abbreviations

ED – Emergency Department
IQR – Interquartile range
RCEM – Royal College of Emergency Medicine

Key Notes

- Incidence of ingestion of rare earth magnets is increasing and is associated with significant complications.
- An RCEM safety flash and guidelines were released in May 2021 to guide management.
- The new guideline has helped to streamline clinical practice.

Introduction	"Super-strong" or "rare-earth" magnets are made from a mixture of iron, boron and neodymium powders, and are up to 30 times stronger than plain iron magnets.[1,2] They tend to have a small surface area and are capable of attracting each other through tissues,[3,4] leading to fistula formation and perforation.[3,5] Not all patients will give a history of magnet ingestion[6] and, as the magnets often occlude any perforation, symptoms may be non-specific and mild.[2] Case reports of harm from super-strong magnets begin in the medical literature around 2002.[1,6,7] More recently, magnets have also become part of social media "crazes".[8,9,10,11] Despite legislation stipulating that toys containing magnets should carry a warning,[12] the incidence of harm from these magnets is increasing.[7,13] In 2015, the North American Societies of Paediatric Gastroenterology, Hepatology and Nutrition released an algorithm for the management of ingestion of magnets.[6] However, this has not been internationally adopted, and there has been lack of consensus on ideal management.[2] In May 2021, a National Patient Safety Agency Alert was released after an increasing incidence of magnet ingestion in children requiring intervention was identified.[14] A Royal College of Emergency Medicine (RCEM) Best Practice Guideline[15] was consequently published regarding the management of ingestion of magnets in children. This gives a management pathway for children and young people with single magnet ingestion and recommends paediatric surgical review for those with multiple magnet ingestion. We introduced these guidelines into practice in our Emergency Department (ED) on the 19th of May 2021 and have audited practice before and after introduction, aiming to compare current management with the guideline and evaluate the impact of the guideline.
Patients and Methods	**Study Design** A retrospective notes-based audit was undertaken comparing the management of young people presenting with magnet ingestion before and after the introduction of the guidelines. **Study Setting** This was a single centre audit in Alder Hey Children's Hospital: a tertiary referral centre, which receives more than 60,000 patients per year to the ED. Patients presenting directly to the ED, and tertiary transfers to the ED from peripheral hospitals for assessment by a paediatric surgeon (all of which attend via the ED), were included in the study. **Objectives:** <u>Primary Objective</u>

	To describe the demographics and management of patients presenting with magnet ingestion to Alder Hey Children's Hospital over five years. <u>Secondary Objective</u> To compare management of magnet ingestion before and after introduction of the new national guidance and audit practice against guidance. **Inclusion Criteria** Data were collected relating to children and young people, aged under 16 years, presenting to Alder Hey Children's Hospital with magnet ingestion between January 2016 and April 2021, and then between May 2021 and March 2022. Patients were identified through a search of coding on Meditech (electronic patient management system) using the Snomed coding system, and through radiology requests. **Dataset Creation** Through searches of Meditech and radiology requests, all cases where there was mention of "foreign body" were screened to identify those with actual or suspected magnet ingestion. Only patients in whom magnet ingestion was suspected (in the history) or proven, were included in the final analysis. The full attendance (including any admission) was reviewed. For patients who were asked to return or had an unscheduled return for the same complaint, data from the re-attendance was included as the same episode. Patients presenting with a separate episode of ingestion were listed as a separate case. All data were obtained retrospectively from the hospital picture archiving communication system and Meditech. For each patient, data were collected relating to demographics, investigation and management. The management of each case was compared to each recommendation within the new guideline. Data were collected to compare current practice against the following recommendations from the RCEM Best Practice guideline: [15] • "Do not use metal detectors for the assessment of children with suspected rare earth magnet ingestion" • "Chest X-ray and abdominal X-ray (with the patient lying down, ideally anterior-posterior) should be requested to assess both the position of any magnets and the number of magnets." • "In the case of a single magnet being identified on an abdominal X-ray, a lateral abdominal X-ray should also be requested to confirm that only one magnet has been ingested". • "Repeat abdominal X-rays should be performed after 6-12 hours in children with single magnet ingestion who are asymptomatic and meet the discharge criteria"

	• "The following patients should be considered suitable for discharge after rare earth magnet ingestion if they meet all of the following criteria: single magnet ingestion, accidental ingestion, no co-morbidities, tolerating oral intake, presents within 24hr of ingestion, care-giver able to provide close observation" **Comparative Analysis** This was a convenience sample of patients attending the paediatric ED between January 2016 and March 2022. There was no sample size calculation. Categorical data were compared before and after guideline introduction using Fisher's Exact Test if two variables were compared and χ^2 test if three variables were compared. Significance was taken as $p<0.05$. **Patient and Public Involvement** There was no patient or public involvement in the design, conduct, or reporting of this study. **Ethical Approval** As this was an audit, ethical approval was not required. The audit was registered locally – audit number 6291.
Results	Overall, during the study period, there were 4,819 presentations with actual or suspected foreign body ingestion, of which 159 involved a magnetic foreign body (Figure 1). Incidence of magnet ingestion increased during the study period, with variation across age groups. Presentations of children of secondary school age peaked in 2019, whereas presentations of younger children continue to rise (Figure 2). <u>Pre-guideline cohort</u> Between January 2016 and April 2021, 4,162 patients presented with foreign body ingestion of whom 104 (2.5%) reported ingestion of a magnet and/or a magnet was subsequently identified (Figure 1). 5 of these were excluded: four had ENT presentations (3 in the nose and one in the hypopharynx) and one patient had insufficient information to collect meaningful data. The patient with insufficient information had ingested multiple magnets, and had a laparotomy, but no further information is available. One patient presented twice, with two separate ingestions, and was included as two separate episodes. Thus, there were 100 patient episodes included prior to May 2021. <u>Post-guideline cohort</u> During the 10-month period following introduction of the guideline, there were 657 patient episodes with foreign body ingestion, including 55 (8.4%) with magnet ingestion (Figure 1). Four were ENT presentations and 13 were duplicates (patients who returned for repeat x-rays etc.), which left 38 patients included in analysis. The demographics of patients

	presenting before and after introduction of the guideline were comparable (Table 1). Figure 3 describes the patient journeys against audit standards. In the guideline, management of multiple magnet ingestion includes only a paediatric surgical review, but this figure includes data for admissions and follow-up abdominal x-rays as well. <u>Data against each of the audit standards is presented below:</u> *"Do not use metal detectors for the assessment of children with suspected rare earth magnet ingestion"* In the pre-guideline period, the metal detector was used in 19/98 (19.4%) of cases (data not available for 2 cases), and after introduction of the guideline, the metal detector was used in 3/38 (7.9%) of cases. *"Chest X-ray and abdominal X-ray (with the patient lying down, ideally anterior-posterior) should be requested to assess both the position of any magnets and the number of magnets."* Pre-guideline, 6 patients did not have x-rays performed, 4 of which had use of a metal detector, whereas x-rays were performed in all 38 cases after introduction of the guideline. Since introduction of the guideline a complete chest and abdominal x-ray was done initially in 28/36 cases (77.8%). *"In the case of a single magnet being identified on an abdominal X-ray, a lateral abdominal X-ray should also be requested to confirm that only one magnet has been ingested".* In the pre-guideline period, a lateral view was performed in only one case where a single magnet was seen on the first view (1/25, 4%). In the post-guideline period, lateral x-rays were performed in 4/12 cases (33%) where a single magnet was seen on the anterior-posterior x-ray. (Of note, lateral views were also performed in two additional cases where more than one foreign body had already been seen on the anterior-posterior x-ray). *"Repeat abdominal X-rays should be performed after 6-12 hours in those children who are asymptomatic, have ingested a single magnet and meet the discharge criteria"* Pre-guideline, follow-up x-ray was performed on 40/79 (51%) patients where a magnet was seen. (38/54 (70%) with multiple magnet ingestion, 2/25 (8%) with single magnet ingestion, as seen on x-ray). In the pre-guideline group, follow-up x-ray was performed a median of 24 hours after the first radiograph (IQR 18-48hrs, range 4-120hours). Following introduction of the guideline, follow-up x-rays were performed on 28/31 (90%) of those with a visible magnet on the original x-ray. The 3 without further radiograph had ingested a single magnet, therefore 9/12 (75%) of those with single magnet ingestion (as seen on x-ray) had a

	follow-up radiograph. Follow-up radiograph was performed a median of 13 hours after the initial radiograph (IQR 12-16hrs, range 5-75 hrs) in the post-guideline group. *"Interpretation of the abdominal x-ray and the finding of progression of the rare earth magnet through the gastrointestinal tract should be formally confirmed by a radiologist"* Since introduction of the guideline, decision making was only based on a radiologist report in one case out of 26 (3.8%) where a magnet was still seen on the follow-up x-ray (this represented 1/12 (8.3%) cases with a single magnet). *"The following patients should be considered suitable for discharge after rare earth magnet ingestion: single magnet ingestion, accidental ingestion, no co-morbidities, tolerating oral intake, presents within 24hr of ingestion, care-giver able to provide close observation"* Patient disposition from ED is summarised in Table 2. In both time periods, the majority of patients were discharged. Prior to May 2021, two of these re-presented with symptoms and were admitted, but ultimately did not require surgical intervention. Pre-guideline, 19/100 (19%) patients were admitted, 13 (13%) of whom required procedural intervention. Post-guideline, 10/38 (26.3%) patients were admitted, 5/38 (13.2%) of which had operative intervention. One patient who was discharged for serial x-rays was subsequently admitted for operative intervention after failure of the magnets to progress. Retrospective comparison of management of admissions in the pre-guideline cohort against the new guideline showed that all 20 admissions were appropriate. However, of the 80 who were discharged 40 (50%) would not have met the discharge criteria. For 5/80 (6%) patients, there was not enough information to assess whether they would have met the new discharge criteria. Following introduction of the guideline, 27/38 patients were discharged. 17 of these met the discharge criteria. 38% (10/26) who were discharged after implementation of the new guidelines, would not have met the discharge criteria, but all were discussed with the surgical team.
Discussion	In this paper, we report the demographics and incidence of magnet ingestion, and assess current management against the recently published RCEM Best Practice Guideline,[15] in the hope this might inform future service planning and best implementation of the guidance, in our hospital and in other hospitals where magnet ingestion is seen less frequently. This study is limited by the fact that it is a retrospective audit from notes review. A strength is that we have few missing data, and this is a complete cohort across a 6-year time-period.

In keeping with other studies,[13] we found a rising incidence of magnet ingestion. We suggested this relates to social media trends and the increasing availability of magnet-containing toys, particularly online.

Additionally, our data shows a possible relationship with lockdown during the SARS-CoV-2 virus pandemic. The incidence of magnet ingestions rose significantly in 2019, fell in 2020, but rose again in 2021. In the UK, lockdown dramatically affected school attendance and social mixing of teenagers in 2020, which may have reduced the influence of magnet-related trends. There may have still been magnets in the home for younger siblings to access and ingest, which may explain the increase in presentation of younger age groups through this time period. As children are now back at school, we expect incidence in all age groups to continue to rise.

Across the whole study period, there was heterogeneity in the investigation and management of patients in our cohort. This appeared to reduce after implementation of the RCEM Best Practice Guideline.[15] We found our practice largely followed the guideline in most but not all aspects. The challenges we have faced locally are likely to be relevant to other hospitals who see children with magnet ingestion.

A metal detector was used in at least 19 cases before introduction of the guideline and 3 cases after the guideline was introduced. Use of a metal detector for suspected magnet ingestion is contraindicated in the new guidelines due the theoretical risk of moving the magnet and causing bowel wall damage due to the attraction of the magnet to the metal detector. In some cases, in our pre-guideline cohort, patients were discharged with no further investigations, based on no detection of metal, or detection of metal below the diaphragm. Following introduction of the guideline, use of the metal detector appeared to reduce and no patients were discharged based on the use of a metal detector. However, work is still needed to ensure that the metal detector is not used in any cases.

Lateral x-rays are important in the detection of multiple ingested magnets, even when ingestion of only one magnet is suspected. This is because magnets that are stuck together may appear as one on an anterior-posterior film and may only be seen as multiple on the lateral x-ray. However, lateral x-rays are not required when multiple magnets have already been identified on the anterior-posterior x-ray and would represent an unnecessary radiation exposure. In the pre-guideline cohort, lateral views were only performed in one case, which means we cannot be sure the other cases of single magnet ingestion were truly single magnets. Following introduction of the guideline, lateral x-rays were performed more often, but were still underutilised. This may have

been in part due to interpretation of the guideline, with clinicians believing that a lateral was not required if the patient stated they had only ingested one magnet. It should also be noted that lateral views were performed in two additional cases where more than one magnet was detected on the anterior-posterior view. This is outside the recommendations of the guidelines, may represent an unnecessary x-ray and a possible misinterpretation of the guidelines. An awareness of this potential for misinterpretation of this part of the guideline is important, and it may be that local policies can be worded in a way to mitigate this risk.

According to the guideline, it is necessary for patients to return for repeat x-rays to ensure progression of the magnet(s). However, if these x-rays are done too early, this represents unnecessary radiation exposure, as well as taking patient and clinical time. In the post-guideline introduction cohort, at least two patients were brought back earlier than recommended: 6 hours after ingestion, rather than 6 hours after the first x-ray. This, again, probably represents a misinterpretation of the guidelines, which can be mitigated by wording of local policies.

The guideline recommends that follow-up x-rays should be radiologist-reported. This is to prevent multiple follow-up x-rays where the magnets are thought to be moving but are, in fact, stationary on repeated films. The need for radiologist-reported follow-up x-ray at 6-12 hours after the first x-ray is only stipulated in the guidelines for single magnet ingestion. For multiple magnet ingestion, the advice is simply to discuss with a specialist paediatric surgical centre. There is no guidance for this group thereafter. However, it would follow that these patients should also have a radiologist-reported follow-up x-ray, so this was included in the flowchart in Figure 3 (in italics). As it was difficult to assess whether follow-up decisions were made with a radiologist-reported x-ray from older notes, this was only assessed for the post-guideline cohort.

If a radiologist's report is required for decision making, this may require hospitals to adapt their reporting policies so that a returning patient can have the x-ray reported and can be discharged within the 4-hour Emergency Department target.

Our data shows that presentations of magnet ingestion continue to increase. Considering the patient safety incidents noted by the National Patient Safety Agency,[14] this makes the RCEM best practice guideline[15] vital. However, we note that the guideline places more demands on resources, with increased admissions and number of returning patients. This has relevance to our cohort, but also to smaller hospitals where magnet ingestion is seen less frequently.

	In our cohort, none of the patients who had ingested a single magnet went on to require operative intervention. If further research from the MAGNETIC study[16] confirms our findings, it may be that, if a single magnet is proven (i.e. with an anterior-posterior x-ray of chest and abdomen and lateral x-ray), the follow-up for these children might be relaxed. This would reduce the burden for families and for EDs for what appears to be a lower risk group. The group that required intervention were those who had ingested multiple magnets. Currently, the guideline is not as strict in this group, stipulating only that they require discussion with a paediatric surgical centre. We still found significant heterogeneity in management of this higher-risk group, and we suggest a future version of the guideline might comment further on the management of multiple magnet ingestion. The RCEM Best Practice Guideline[15] provides guidance for a group of patients where there was none before. Our data has shown that the incidence of magnet ingestion continues to increase, and therefore we welcome the introduction of the RCEM Best Practice Guideline for the management of these patients.
Acknowledgements	The RCEM Best Practice Guideline working consensus group for developing the Best Practice Guideline on Super-strong magnet ingestion, which formed the basis of our audit.
Funding	This project did not have any funding.
Competing Interests	Several members of the RCEM Best Practice Guideline working consensus group also work in Alder Hey Children's Hospital Foundation Trust
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Variable	**Pre-guideline (n=100)**	**Post-guideline (n=38)**	**p**
Age (median, IQR, range) (years)	8, 4-12, 1-15	8, 4-11, 0.5-15	
Male:Female	1:1.33	1:1.37	
Number of magnets reported • 1 • More than 1 • Unknown	 35 (35%) 56 (56%) 9 (9%)	 13 (34%) 20 (53%) 5 (13%)	 0.77
Symptomatic at presentation	22/100 (22%)	5/38 (13%)	0.34
Positive finding on x-ray	Radio-opaque foreign body seen 78/100 (78%)	Radio-opaque foreign body seen 31/38 (82%)	

	No radio-opaque foreign body seen 16/100 (16%) No x-ray done (6/100)	No radio-opaque foreign body seen 7/38 (18%)	
Deliberate ingestion	4/100	0/38	0.58
Mental health, or developmental concerns	Mental health (8) Autism (3) Developmental delay (1)	Developmental delay (2)	
Safeguarding concerns	8/100 (8%) (92 not documented)	2/38 (5%) (36 not documented)	
Previous presentations with foreign body ingestion	6/100 (6%)	1/38 (2.6%)	

Table 1: Demographics of patients included before and after introduction of the guideline

	Pre-guideline Cohort (100 magnet ingestions)	Post-guideline Cohort (38 magnet ingestions)

Outcome	Discharged (80)
	• Discharged without medical review or x-ray (5)
	• Discharged for follow-up x-ray (22)
	  ○ Admitted after follow-up x-ray (2)
	• Discharged with safety netting (53)
	  ○ Discharged without x-ray (1)
	  ○ Re-presented (2)
	  ○ Called back for serial x-rays (1)
	
	Admitted at presentation (20)
	• Laparotomy (8)
	• Laparoscopy (1)
	• Gastroscopy (3)
	• Conservative management (8)
		Discharged (27)
		• Discharged without medical review (1)
		• Taken home before being seen-called back (1)
		• Discharged to return for x-ray (11)
		  ○ Subsequent laparotomy (1)
		• Discharged with advice (14)
		  ○ (Including 7 where no FB seen)
		  ○ Discharged then recalled (2)
		Emergency decision unit for follow-up x-ray (1)
		
		Admitted at presentation (10)
		• Laparotomy (3)
		• Laparoscopy (1)
		• Gastroscopy (1)
		• Conservative management (5)

Length of hospital admission	Median 2 days IQR (2-5 days) Range (1-15 days)	Median 2 days IQR (1-4 days) Range (1-11 days)

Table 2: Disposition of patients

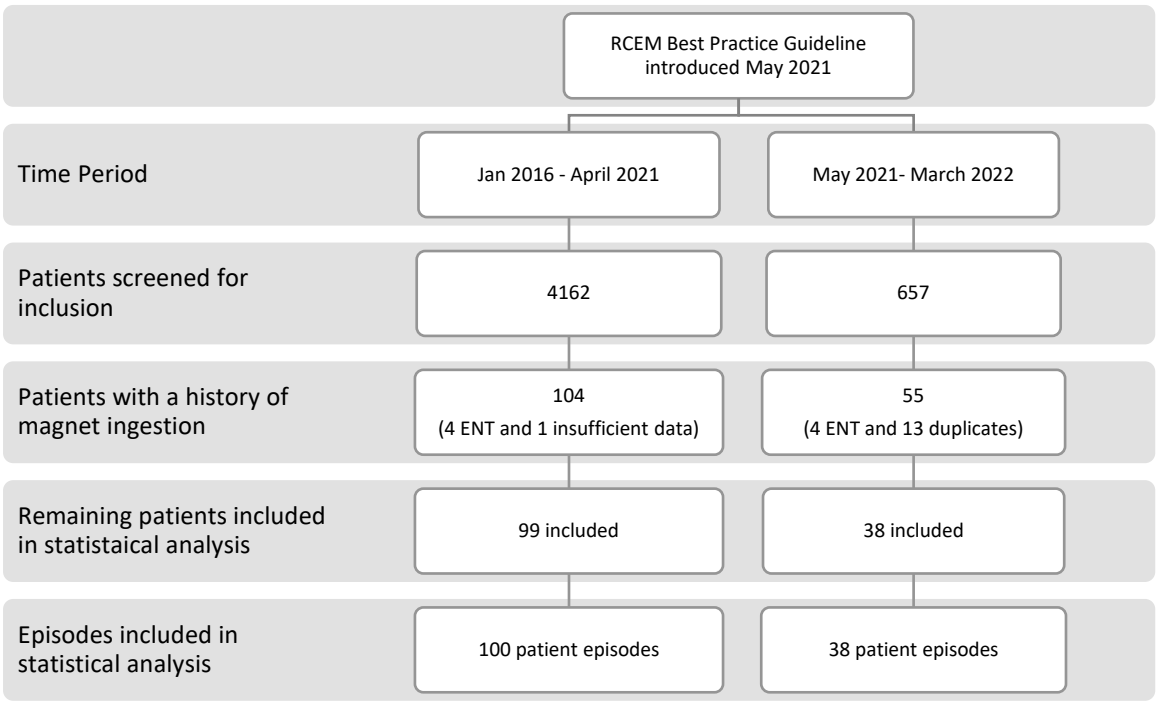

Figure 1: Numbers included in the audit

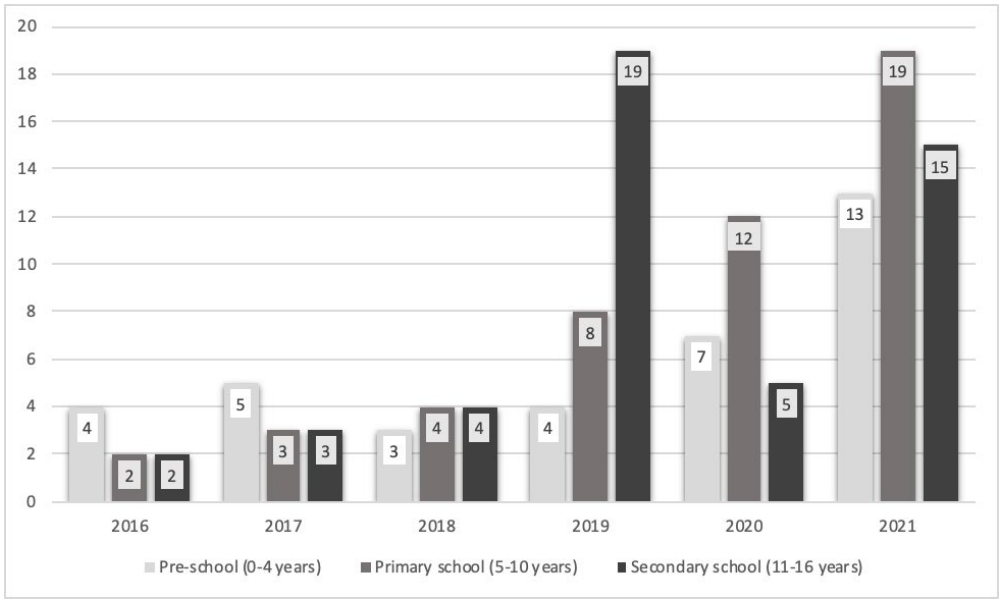

Figure 2: Presentation each year by age group

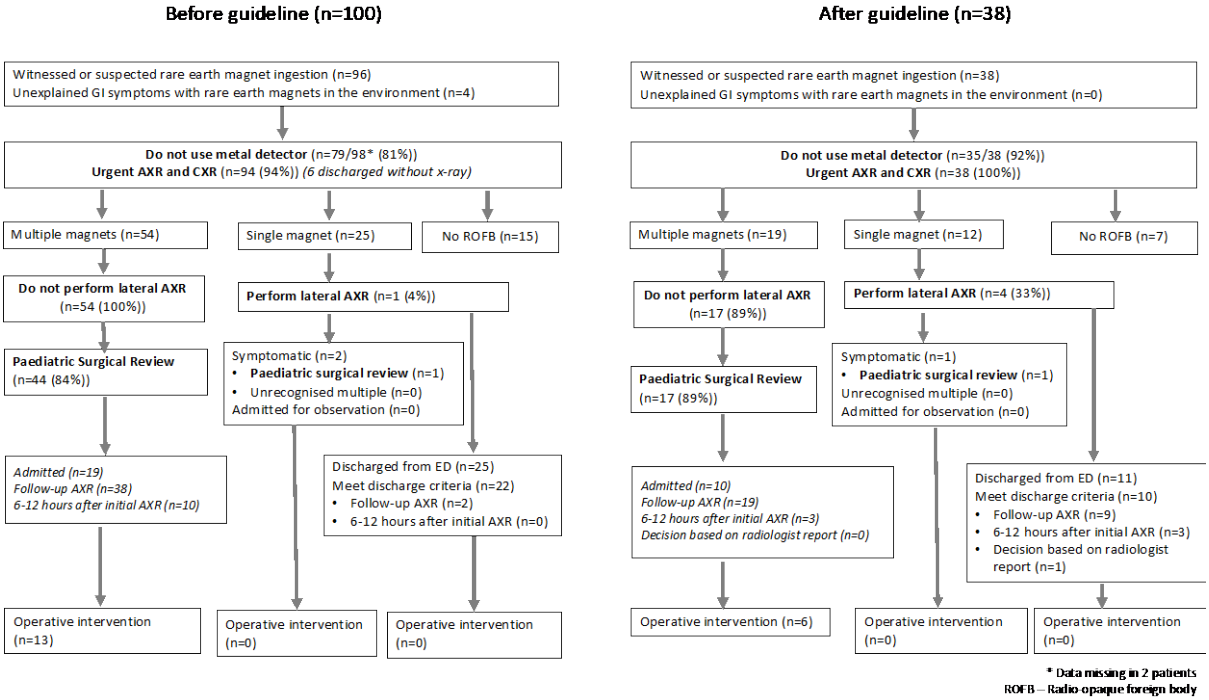

Figure 3: Flow chart of patient journeys before and after introduction of the guideline.