Magnet Ingestion in Children in the United Kingdom: a national prospective observational surveillance study.

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ABSTRACT

Objective Magnet ingestion in children and young people (CYP) is associated with significant harm. We aimed to describe the incidence, circumstances and outcomes of magnet ingestion in CYP in the United Kingdom (UK).

Design Prospective multicentre observational surveillance study.

Setting UK secondary and tertiary level hospitals in urban and rural settings.

Patients CYP ≤16 years of age who ingested ≥1 magnet.

Interventions Data were collected regarding demographics, circumstances surrounding ingestion, clinical features, and management. The primary outcome was the incidence of magnet ingestion in the UK.

Results Between 01/05/2022-30/04/2023, 366 cases of magnet ingestion were recorded, of which 314 met eligibility (median age 8.7 years [IQR 5.1–12.0]). The incidence of magnet ingestion in the UK was at least 2.4/100,000 (95% CI 2.2 – 2.7) CYP per year. CYP sourced magnets from toys (38%), and magnet products were predominantly purchased by parents or caregivers (19%). Magnet-related injuries occurred in 23 (7%) cases and surgery was undertaken in 32 (10%). Single magnet ingestions did not cause magnet-related injury. Swallowing greater numbers of magnets associated with an increased risk of injury (OR 1.1 [95% CI 1.0–1.2], p=0.002). CYP were asymptomatic in 75% of cases, but clinical features on presentation associated with an increased risk of injury (OR 3.8 [95% CI 1.4–10.3], p=0.008).

Conclusions Whilst magnet ingestion in children is uncommon, ingestion of multiple magnets can cause injuries requiring surgery. Greater public and clinician awareness of the associated risks is warranted. This study can inform public health interventions and evidence-based guidelines.

KEY MESSAGES

Evidence before this study

Magnets are dangerous when ingested by children and young people (CYP). Up to 50% of CYP who ingest multiple magnets require endoscopic or surgical intervention. Significant morbidity, including bowel resection and stoma formation, occurs in up to 10%. Multiple studies in Europe and North America have observed an apparent increase in magnet ingestions, but no study has investigated the incidence and circumstances surrounding magnet ingestion in the United Kingdom (UK).

What this study adds

The incidence of magnet ingestions in this study was 2.4/100,000 CYP. This is likely to be a conservative estimate as not all UK centres participated.Magnets were typically sourced from children's toys and products containing magnets are predominantly purchased by parents or caregivers. Social media was directly implicated in 6% of ingestions. Most CYP were asymptomatic, but the presence of clinical features on presentation was associated with a four-fold higher risk of magnet-related injury. Initial radiological imaging rarely showed complications and in a minority of CYP the reported number of magnets ingested was different to the number identified on imaging. No single magnet ingestions resulted in a magnet-related injury. Half of all cases involved the ingestion of multiple magnets, which caused magnet-related injuries in 14%.

How this study might affect research, practice or policy

Greater public awareness of the dangers of magnet ingestion is necessary and warnings at the point of sale appear an insufficient measure to prevent CYP accessing and ingesting magnets. A co-ordinated effort by healthcare professionals, government agencies and relevant charity groups to influence regulations on the sale of high-power magnet products is warranted. Data from the MAGNETIC study can be used to inform evidence-based management guidelines for ingested magnetic foreign bodies. Single magnet ingestions may be treated differently to ingestions of multiple magnets, with fewer radiological investigations and less intensive follow-up. With multiple magnet ingestions, healthcare professionals must be aware of the potential for complications at any time until magnets have passed and should not be reassured by an absence of clinical features or complications on initial imaging. CYP who ingest a greater number of magnets and those with clinical features on presentation are at a higher risk of magnet-related injury.

INTRODUCTION

Foreign body ingestion by children and young people (CYP) is common. Young children place items in their mouth when exploring their environment and older children may accidentally or intentionally swallow objects[1]. Inert items typically pass through the gastrointestinal tract without complications, unless large or sharp. Certain objects interact with gastrointestinal tract tissues to cause harm. Magnets are particularly dangerous when more than one is ingested, as they can attract one another from different locations within the gastrointestinal tract[2]. This can cause bowel obstruction, pressure necrosis, fistulation, or perforation, requiring endoscopic or surgical treatment in up to 60% of children[3,4].

Identifying and treating CYP with complications of magnet ingestion is challenging, as they may not report the event to caregivers and can present late to healthcare services[5,6]. Patients are often asymptomatic, and the decision to intervene is based on identifying complications on radiographs[7]. Non-progression of magnets on serial radiographs is usually interpreted as signifying entrapment of bowel between magnets or fistulation[3,7]. However, assessment of magnet progression is subjective and may be unreliable[8]. Current guidelines suggest repeating radiographs every 6–12 hours, or 2–3 days if the child is asymptomatic[9,10]. However, there remains variability in management, which results in a high burden of investigations, radiation exposure and resource use[3,4]. Early identification of CYP at risk of complications may limit morbidity, prevent unnecessary investigations, and reduce the need for intervention.

Several studies have observed an apparent increase in presentations to healthcare services following magnet ingestion[2,11–13]. This may be due to the influence of social media, increasing availability of high-power magnets, or other factors[14]. However, the incidence of magnet ingestions, sources of these magnets, circumstances surrounding ingestions, and variation in management in the United Kingdom (UK) are unknown. These data are important to inform public health policy actions to limit harm from magnets and enable the development of evidence-based guidelines.

In this prospective observational surveillance study, our primary aim was to determine the incidence of magnet ingestion in CYP in the UK. Secondary objectives included examining the circumstances surrounding magnet ingestion, the investigations and management strategies utilised, and patient outcomes.

METHODS

This prospective observational surveillance study was undertaken in Paediatric Emergency Research in the UK and Ireland (PERUKI) sites, representing secondary and tertiary level hospitals in urban and rural settings[15]. CYP ≤16 years of age, who presented between 01/05/2022–30/04/2023, reporting the ingestion of ≥1 magnetic foreign body, were eligible for inclusion. Patients were excluded if they had ingested only non-magnetic objects or had magnetic foreign bodies only outside the gastrointestinal tract.

Due to the rarity of magnet ingestion and the necessity to report all cases, we sought approval from the Confidentiality Advisory Group to collect data without patient consent (22CAG0031). Patients and the public were involved in the study design and were consulted on the appropriateness of opt-out consent. Approvals were obtained from the UK Health Research Authority (22/NW0050). This study is reported in accordance with STROBE[16].

Data were collected and managed in a secure online Research Electronic Data Capture tools (REDCap) database[17]. Participants were identified and screened by the clinical teams, who uploaded prospective data. Participation did not change management decisions made by the local clinical team.

On first presentation to hospital, treating healthcare professionals (HCP) completed a case report form (CRF) detailing demographic data, circumstances of ingestion, clinical features, initial investigations, and management. Further investigations, management and outcome data were collected at seven and 28-days post-presentation. Reminders to complete CRF were sent to the initial treating HCP. If a CYP was transferred between HCP at a single hospital, or between different hospitals, all teams were asked to complete a CRF to capture complete incident data. The patient's unique NHS number was used to consolidate duplicate entries.

Socioeconomic status was defined using nation-specific index of multiple deprivation (IMD) data from 2017 (Northern Ireland), 2019 (England and Wales) and 2020 (Scotland). Successful endoscopic or surgical treatment was defined as removal of all magnetic foreign bodies, so that the patient required no further interventions. Magnet-related injury was defined as harm occurring at any time as a direct result of magnet ingestion.

The primary outcome was the minimum incidence of magnet ingestions in CYP in the UK during the one-year surveillance period. Secondary outcomes included determining whether sociodemographic and clinical factors were associated with the ingestion of magnets and the development of magnet-related injuries.

Prior to analysis, all entries were cleaned and validated. Duplicates were consolidated. Records of patients not meeting eligibility and records with insufficient data to inform the study primary outcome were removed.

Incidence was calculated using mid-2021 UK population census data for CYP aged 0–16 years and 95% confidence intervals (CI) were calculated assuming a Poisson distribution. Skewed data are reported as median and interquartile range (IQR) and were compared using the Mann-Whitney U test. Categorical data were compared using Chi-squared or Fisher exact tests, as appropriate. Correlation was assessed using Spearman's rank correlation coefficient. Logistic regression analysis was undertaken to identify factors associated with magnet-related injury. Data are described as odds ratios (OR) with 95% CI. All tests were two-sided. A p-value <0.05 was considered significant. Analysis was conducted in SPSS (v29.0.0) and GraphPad (v10.2.3).

RESULTS

Patient cohort

A total of 366 records were uploaded to the database. Thirty-eight duplicate entries were consolidated. Eleven records not meeting eligibility and three records with insufficient data were excluded. The final dataset for analysis included 314 unique episodes of magnet ingestion, representing data from 66 hospitals (Table 1).

The incidence of magnet ingestion in our study was 2.4/100,000 CYP per year (CI 2.2–2.7). Of the 314 presentations, 262/314 (83%) cases were reported from England, 41/314 (13%) from Scotland, 6/314 (2%) from Wales and 5/314 (2%) from Northern Ireland.

CYP reported how many magnets they had ingested in 301/314 cases (96%). The median number of magnets ingested was 2 (IQR 1–2, range 1–52). Single magnet ingestions were reported by 137/301 (46%) and multiple magnet ingestions by 164/301 (54%).

Socio-demographics and circumstances

Median age was 8.7 years (IQR 5.1–12.0) and 164/314 (52%) cases were male (Table 1, Supplementary Figure 1). The highest proportion of ingestion cases was in children aged 12 years. The median IMD decile was five (IQR 2–8) and the highest proportion of ingestions was decile one (16%) (Supplementary Figure 2). A non-significant negative correlation was observed between increasing IMD decile and frequency of magnet ingestions

(Spearman's ρ=-0.50 [CI -0.86–0.21], p=0.143). Of the 294/314 (94%) cases for which information on previous involvement with social services was available, 36 children (12%) had prior involvement.

Fourteen CYP (4%) had an existing diagnosis of anxiety or depression, whilst 28/314 (9%) had autism spectrum disorder (ASD), and 7/314 (2%) had attention deficit hyperactivity disorder (ADHD). Six had previously ingested magnetic foreign bodies, of whom two had a diagnosis of depression and three had a diagnosis of ASD. All six had previously committed acts of self-harm, and four had previously ingested non-magnetic foreign bodies.

Magnets were sourced from toys or games in 118/314 (38%) cases (Table 2). Magnet containing products had been purchased by parents or caregivers in 60/314 (19%). Social media was directly implicated in 20/314 (6%) cases: 17/20 (85%) were female and 19/20 (95%) ingested multiple magnets. All 20 referred to mimicking a tongue piercing with magnets. Twelve specifically mentioned the social media site "TikTok".

Presentation and investigations

In 174/314 (55%) cases, the primary point of healthcare contact was attending ED. Secondary presentation to ED after discussion with emergency services or formal phone/online advice (NHS 111) occurred in 44/314 (14%) and 39/314 (12%) cases respectively. Two (1%) attended ED after seeing their General Practitioner. Fourteen (8%) cases were transfers from another hospital and 10 (3%) were planned reviews (either from the same or a different hospital). All inter-hospital transfers were for paediatric surgery services.

Approximate date and time of magnet ingestion was reported in 306/314 cases (97%). The median time from magnet ingestion to presentation was 2.4 hours (IQR 1–8). The longest time from ingestion to presentation was 22 days.

Most CYP had no clinical features; only 80/314 (25%) had at least one symptom or sign (Supplementary Table 1). The commonest clinical features were abdominal pain (48/314, 15%) and tenderness (20/314, 6%). Children who had ingested multiple magnets (confirmed radiologically) were not more likely to have clinical features on presentation (11% for single *versus* 14% for multiple, p=0.404).

The median number of magnets identified on imaging was 2 (IQR 1–2). Single magnets were identified in 123/314 (39%) cases and multiple magnets in 170/314 (54%). Eight (3%) received no diagnostic imaging to confirm magnet ingestion; all of these were suspected single magnet ingestions (Supplementary Table 2).

Five who reported multiple magnet ingestions had a single magnet or no magnets on imaging. Conversely, 11 who had reported single magnet ingestions had multiple magnets identified on imaging. Initial imaging identified complications in one child who developed small bowel obstruction after ingesting multiple magnets (performed 17 days after ingestion). No other complications were identified on presentation imaging.

Management of magnet ingestion

After ED management (Figure 1), 141/314 (45%) cases underwent further imaging, of which 139/141 (99%) had plain radiographs (Supplementary Table 2). In 30/146 (21%) cases the magnets had not progressed from the initial imaging within seven days of ingestion, and two children had developed new complications: one perforation and one gastrointestinal fistula. Overall, the median number of plain radiographs performed per patient was 2 (IQR 0–3). Five or more radiographs were performed in 24 CYP, and four received ≥10.

Of 247/314 (79%) cases which did not require intervention, 112/314 (45%) were multiple magnet ingestions. Conservative management was more common in single magnet ingestions (94% single *versus* 67% multiple, $p<0.001$).

Endoscopy was performed in 21/314 (7%) cases, with a median time to procedure of 1 (IQR 0 – 3) day. Magnets were successfully removed endoscopically in 9/21 (43%) children and median time to endoscopy was not associated with success (1 day [IQR 0–1] success *versus* 1 day [IQR 0–4] failure, $p=0.803$). Of the 12 unsuccessful cases, seven underwent surgery. There were no procedural complications.

Thirty-two (10%) CYP underwent surgery with a median time to surgery of 3 (IQR 2–7, range 0–32) days (Table 3). The most common indication was failure of magnets to progress on serial radiographs (21/32, 66%). Most underwent laparotomy (14/32, 44%), nine children underwent laparoscopic magnet removal, and nine children were converted from laparoscopy to open surgery. Injuries caused by magnet ingestion were identified in 23/314 (7%) cases intra-operatively (Table 3). Bowel resection was performed in five patients and four required parenteral nutrition. One patient developed a post-operative wound infection. Date of discharge post-surgery was recorded in 20 cases, and median length of stay post-procedure was 1 (IQR 1–4) day.

Factors related to magnet-related injury

A greater number of magnets were ingested by children who developed a magnet-related injury (4 [IQR 3–12] in the injury group *versus* 2 [IQR 1–2] in the non-injury group, p<0.001) (Table 4). Similarly, children who developed a magnet-related injury presented later following ingestion (5 hours [IQR 2–36] in the injury group *versus* 2 [IQR 1–7] in the non-injury group, p=0.046). A significantly greater proportion of children with clinical features on presentation suffered a magnet-related injury compared to those with no clinical features (52% *versus* 23%, p=0.002). Patient age, sex and ethnicity were not significant.

On multivariable logistic regression, an association was observed between increasing numbers of ingested magnets and the risk of magnet-related injury (OR 1.1 (CI 1.0–1.2), p=0.002). Similarly, the presence of clinical features on presentation was associated with an increased risk of injury (OR 3.8 (CI 1.4–10.3), p=0.008) (Supplementary Table 3).

DISCUSSION

The incidence of magnet ingestion in the UK during the study period was at least 2.4/100,000 CYP per year. Toys and games, which are predominantly purchased by parents or caregivers, were the most common source of magnets. Delayed presentation was associated with a higher incidence of magnet-related injury, and while CYP are often asymptomatic, presence of symptoms on presentation was associated with a four-fold increased risk of injury. Magnet-related injuries occurred in 14% of multiple magnet ingestions. No magnet-related injuries were identified in single magnet ingestions but increasing numbers of ingested magnets were significantly associated with an increased risk of injury.

Low socioeconomic status is recognised as being associated with childhood injury morbidity and mortality[18]. We observed that the frequency of magnet ingestions was highest amongst children in the lowest IMD decile. Few studies have investigated the relationship between socioeconomic status and paediatric foreign body ingestion. Chen *et al.* observed that residential instability and maternal deprivation were independently associated with foreign body ingestion in a cohort of 680 children in Canada[19]. Further research is required to understand the relationship between deprivation and foreign body ingestion to identify potential interventions.

There have been several reports of magnet ingestion inspired by social media in the UK news, particularly the "viral trend" of placing magnets in the mouth to mimic tongue piercings[13]. In our study, 6% of cases implicated social media, all replicating a tongue piercing. Most were female and 95% ingested multiple magnets. Future efforts to reduce magnet ingestion could include placing greater responsibility on social media companies to ensure that posted content does not promote self-injurious behaviours.

CYP that may be at a higher risk of magnet-related injuries are those with behavioural diagnoses, such as ASD and ADHD[20]. A diagnosis of ASD was over-represented in the CYP included in this study, which corroborates previous observations[3]. Similarly, a cohort of CYP with mental health diagnoses who ingest magnets as a form of self-harm has been identified[21]. Caregivers to CYP in these high-risk groups should be particularly aware of the dangers of magnet ingestion. Manufacturers of products targeted to these groups should also explore methods to minimise risk.

This study confirms several key findings regarding the management of magnet ingestion in CYP. When presenting to healthcare services following magnet ingestion, patients are typically asymptomatic[22]. The presence of symptoms does not reliably distinguish between single and multiple magnet ingestions. Our findings corroborate research that demonstrates an association between symptoms and signs, and an increased risk of magnet-related injury[23]. Plain radiographs rarely identify complications on presentation and normal imaging findings should not reassure HCP. No cases of single magnet ingestion resulted in magnet-related injuries, confirming that single magnet ingestions can be managed differently to multiple[5,9,10]. Although, single magnets may still require intervention if causing obstruction or the child is symptomatic[3].

The strengths of the MAGNETIC study are its large sample and prospective data collection by HCP. However, the incidence is likely to be an underestimation. Despite our best efforts, not all hospitals in the UK contributed data and therefore, not all cases would have been captured in this dataset. No internal audits were performed at any participating sites to confirm complete data collection. Similarly, due to geographic variability in reporting, IMD data may not be nationally representative. Limitations of the study also include the presence of unknown or missing datapoints for secondary outcomes.

This study has confirmed previous reports that multiple magnets are dangerous when ingested by children. Single magnets do not appear to cause injuries when ingested, and therefore HCP should have a high index of suspicion for multiple magnet ingestions. Despite current legislation mandating warnings at the point of sale, magnet ingestions continue to occur. Further work must focus on raising public awareness of this issue and standardising guidelines based on published evidence. A co-ordinated effort by HCP, government agencies and relevant charity groups to limit the sale of high-power magnets is warranted.

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DATA SHARING

Anonymised data from MAGNETIC will be made available upon reasonable request to the authors.

FIGURES

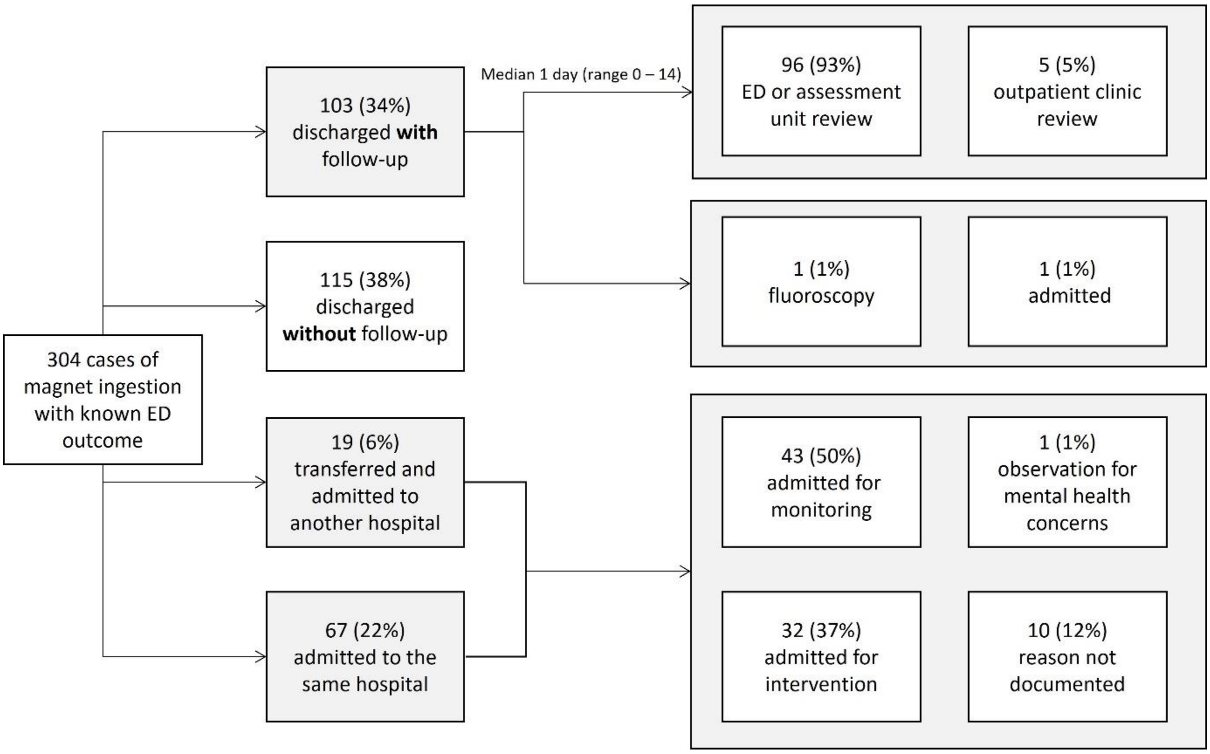


Figure 1: Summary of emergency department (ED) management (n = 304). Of the 115 patients discharged home without follow-up, 18 (16%) were radiologically confirmed multiple magnet ingestions. No patients discharged from the ED without follow-up underwent subsequent surgical intervention.

TABLES

Table 1: Characteristics of patients on presentation to a healthcare professional. IQR – interquartile range.

	All patients (n = 314)
Median age at presentation in years (IQR)	8.7 (5.1 – 12.0)
Sex	
Female	150 (48%)
Male	164 (52%)
Ethnicity	
Asian or Asian British	31 (10%)
Black, Black British, Caribbean or African	4 (1%)
Mixed or Multiple Ethnic Groups	4 (1%)
Other Ethnic Group	34 (11%)
White	241 (77%)
History of social services involvement	
Yes	36 (12%)
No	258 (82%)
Unknown/unspecified	20 (6%)
Siblings (n = 141)	
Yes	111 (79%)
No	30 (21%)

Table 2: Summary of circumstances of magnet ingestion.

	All patients (n = 314)
Reason ingestion was identified	
Witnessed by parent/caregiver	50 (16%)
Witnessed by another person	21 (7%)
Reported by patient	188 (60%)
Unwitnessed and unreported	12 (4%)
Patient symptomatic	13 (4%)
Other	13 (4%)
Social media implicated	
Yes	20 (6%)
No	285 (91%)
Unknown/unspecified	6 (2%)
Ingestion intentional	
Yes	62 (20%)
No	248 (79%)
Unknown/unspecified	4 (1%)
Source of magnets	
Toys or games	118 (38%)
Home devices	4 (1%)
Jewellery	24 (8%)
Executive toys	0 (0%)
Other	32 (10%)
Unknown/unspecified	134 (43%)
Purchaser of magnets	
Patient	6 (2%)
Parent/caregiver	60 (19%)

Siblings	2 (1%)
Friends	9 (3%)
Other	15 (5%)
Unknown/unspecified	222 (71%)

Table 3: Characteristics of 32 children managed surgically. XR – plain film radiographs, PN – parenteral nutrition via a central venous catheter.

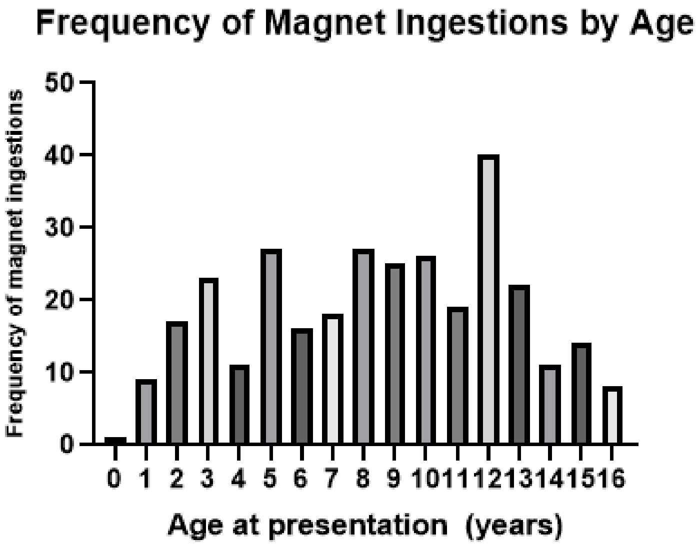
Age (yrs)	Sex	Number Magnets Ingested	Indication for Surgery	Procedure	Surgical Findings and Magnet-Related Injury	Type of Magnets Removed	Surgical Complication
1.7	Male	3	Clinical and radiological suspicion of complications	Laparoscopy converted to open	Ileal and caecal obstruction and perforation	High-power ball magnets	None
1.8	Female	2	Failure to progress on XR	Laparotomy	Small bowel perforation	High-power ball magnets	None
1.8	Male	9	Clinical suspicion of complications	Laparotomy	Small and large bowel perforations	High-power ball magnets	None
2	Male	3	Failure to progress on XR	Laparoscopy converted to open	Small and large bowel mucosal damage	High-power ball magnets	Wound infection
2.7	Female	3	Failure to progress on XR	Laparoscopy	None – removed from stomach	High-power ball magnets	None
2.8	Male	3	Failure to progress on XR	Laparotomy	Fistulation between posterior stomach and splenic flexure of large bowel	High-power disc magnets	None
2.8	Male	18	Failure to progress on XR	Laparotomy	None – removed from small bowel	High-power ball magnets	None
3.1	Female	1	Clinical suspicion of complications	Laparoscopy converted to open	None – removed from large bowel	High-power disc magnet	None
3.9	Male	4	Failure to progress on XR	Laparoscopy	None – removed from caecum via appendix	High-power ball magnets	None
4.7	Female	11	Clinical and radiological suspicion of complications and failure to progress on XR	Laparoscopy converted to open	Fistulation between duodenum and terminal ileum, received 7 days of PN	High-power bar magnets	None
4.8	Male	22	Clinical suspicion of complications	Laparotomy	Stomach obstruction	Fridge magnets	None
4.9	Male	52	Clinical and radiological suspicion of complications and failure to progress on XR	Laparotomy	Small bowel perforation with intra-abdominal abscess, fistulation between jejunum and ileum, and ileum and caecum, bowel resection, received 7 days of PN	High-power ball magnets	None
5.5	Male	20	Clinical suspicion of complications	Laparoscopy	Fistulation jejunum to jejunum, bowel resection	High-power ball magnets	None
6.7	Male	13	Failure to progress on XR	Laparoscopy	Fistulation small bowel to small bowel, bowel resection	High-power ball magnets	None
8.1	Male	4	Clinical suspicion of complications and failure to progress on XR	Laparoscopy converted to open	Small bowel obstruction, bowel resection	Disc magnets	None
8.3	Female	2	Failure to progress on XR	Laparoscopy	Ileo-caecal valve obstruction	High-power ball magnets	None
8.8	Male	2	Failure to progress on XR	Laparoscopy	None – removed from caecum	High-power ball magnets	None
9.2	Female	2	Failure to progress on XR	Laparoscopy	None – removed from caecum	High-power ball magnets	None
9.6	Female	18	Clinical and radiological suspicion of complications	Laparotomy	Small bowel mucosal damage, received 7 days of PN	High-power ball magnets	None
9.6	Male	1	Clinical suspicion of complications	Laparotomy	None – removed from stomach	Disc magnet	None
11	Male	4	Clinical suspicion of complications and failure to progress on XR	Laparoscopy converted to open	Fistulation between posterior stomach and jejunum, received 3 days of PN	High-power ball magnets	None

11.1	Female	9	Clinical suspicion of complications	Laparoscopy	None – magnets removed from large bowel	High-power disk magnets	None
12	Male	2	Failure to progress on XR	Laparotomy	Large bowel mucosal damage	High-power ball magnets	None
12	Female	4	Failure to progress on XR	Laparotomy	Small bowel perforation	High-power ball magnets	None
12.3	Female	4	Clinical suspicion of complications and failure to progress on XR	Laparotomy	Fistulation between duodenum and transverse colon	High-power ball and disc magnets	None
12.3	Female	3	Radiological suspicion of complications	Laparoscopy converted to open	Small bowel mucosal damage	High-power ball magnets	None
12.3	Female	3	Failure to progress on XR	Laparoscopy converted to open	Small bowel perforation	High-power disc magnets	None
12.8	Male	4	Failure to progress on XR	Laparoscopy	None – magnets had passed	Unspecified	None
13.6	Male	5	Clinical suspicion of complications and failure to progress on XR	Laparoscopy converted to open	Stomach obstruction	High-power disc magnets	None
13.9	Male	15	Radiological suspicion of complications	Laparoscopy converted to open	Small and large bowel mucosal damage	High-power ball magnets	None
16.3	Male	7	Failure to progress on XR	Laparotomy	Fistulation between stomach and small bowel, and small bowel to rectum	High-power disc magnets	None
16.8	Female	7	Clinical suspicion of complications	Laparotomy	Fistulation between ileum and ileum, bowel resection	High-power disc magnets	None

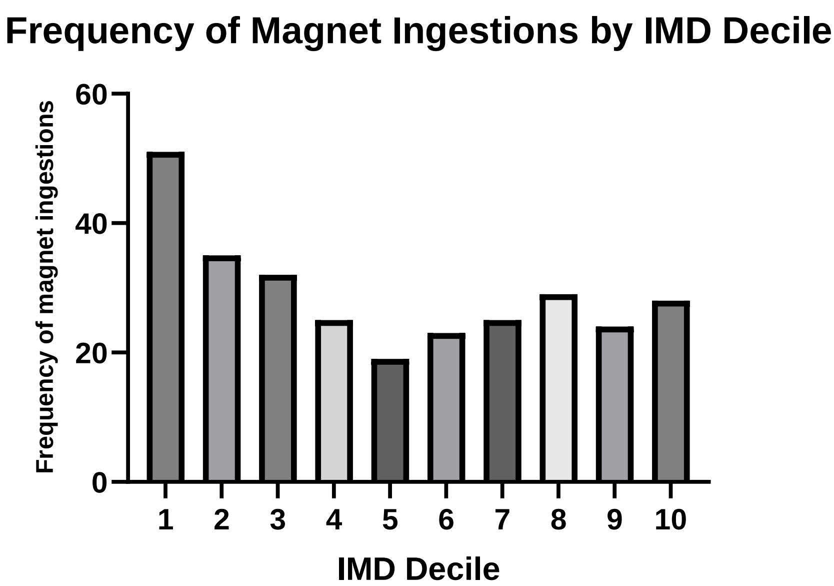
Table 4: Factors associated with magnet-related injury. IQR – interquartile range.

	Injury (n = 23)	**No Injury (n = 291)**	**p-value**
Median age in years (IQR)	8.3 (4.8 – 12.3)	8.7 (5.3 – 11.9)	0.975
Male:female	14:9	150:141	0.389
Ethnicity			0.550
White	18 (78%)	223 (77%)	
Asian	1 (4%)	30 (10%)	
Black	0 (0%)	4 (1%)	
Mixed	1 (4%)	3 (1%)	
Other	3 (13%)	31 (11%)	
Social services involvement	3 (13%)	33 (11%)	0.805
Median IMD decile (IQR) (n = 291)	6 (3 – 8)	5 (2 – 8)	0.320
Past medical history			
Mental health diagnosis	1 (4%)	9 (3%)	0.741
Behavioural diagnosis	5 (22%)	28 (10%)	0.068
Median number of magnets ingested (IQR)	4 (3 – 12)	2 (1 – 2)	*<0.001*
Median hours to presentation (IQR) (n = 306)	5 (2 – 36)	2 (1 – 7)	*0.046*
Presence of clinical features	12 (52%)	68 (23%)	*0.002*
Location of magnets on initial imaging (n = 307)			0.872
Oesophagus	0 (0%)	6 (2%)	
Stomach	6 (26%)	105 (36%)	
Small bowel	9 (39%)	96 (33%)	
Large bowel	5 (22%)	39 (13%)	
Oesophagus and stomach	0 (0%)	3 (1%)	
Oesophagus and large bowel	0 (0%)	1 (0.3%)	
Stomach and small bowel	0 (0%)	17 (6%)	
Small bowel and large bowel	1 (4%)	15 (5%)	
Stomach, small and large bowel	0 (0%)	2 (1%)	
All	0 (0%)	2 (1%)	
Median days to surgery (IQR)	3 (2 – 5)	6 (2 – 7)	0.694
Intervention			
Endoscopy	5 (22%)	16 (5%)	*0.003*
Surgery	23 (100%)	9 (3%)	*<0.001*

SUPPLEMENTAL FIGURES



Supplementary Figure 1: Histogram showing the frequency of magnet ingestions by patient age at presentation.



Supplementary Figure 2: Histogram showing the frequency of magnet ingestions at each Index of Multiple Deprivation (IMD) decile. Data from 291 cases; median decile 5 (interquartile range 2 – 8).

SUPPLEMENTAL TABLES

Supplementary Table 1: Clinical features.

	All patients (n = 314)
Symptoms	
Abdominal pain	48 (15%)
Vomiting	14 (5%)
Chest pain	4 (1%)
Globus sensation	4 (1%)
Cough/choking	6 (2%)
Throat pain	3 (1%)
Other	7 (2%)
None	243 (77%)
Signs	
Abdominal tenderness	20 (6%)
Tachycardia (age defined)	10 (3%)
Abdominal distention	3 (1%)
Abdominal guarding/peritonism	3 (1%)
Pyrexia (>37.5°C)	2 (1%)
Other	2 (1%)
None	281 (90%)

Supplemental Table 2: Imaging modalities used and magnet locations. CXR – chest plain film radiograph, AXR – abdominal plain film radiograph, CT - Computerised tomography. *Patients may receive multiple diagnostic imaging tests. **Magnets may be identified in more than one anatomical location.

	All patients (n = 314)
Diagnostic imaging modality used*	
Metal detector	41 (13%)
Anteroposterior CXR	142 (45%)
Lateral CXR	21 (7%)
Anteroposterior AXR	233 (74%)
Lateral AXR	83 (26%)
Ultrasound scan	1 (0.3%)
CT scan	1 (0.3%)
Endoscopy	2 (1%)
None	8 (3%)
Location of magnets on presentation**	
Oesophagus	13 (4%)
Stomach	135 (43%)
Small bowel	141 (45%)
Large bowel	66 (21%)
Further imaging studies within 7 days (n = 141)*	
XR	139
Contrast study	5
Ultrasound scan	1
CT scan	2

Supplemental Table 3: Multivariate analysis of factors associated with magnet-related injury.

	Odds Ratio	**95% Confidence Interval**	**p-value**
Time from ingestion to presentation	1.01	0.99 – 1.01	0.112
Number of magnets ingested	1.10	1.04 – 1.17	*0.002*
Clinical features on presentation	3.81	1.41 – 10.27	*0.008*