Intraorbital Mercury Removal by DSA Positioning and Route Marking: A 4-year Follow-up

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Research Article

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Abstract

Background: Mercury is a widely used heavy metal. Traumatic mercury residue often leads to contact dermatitis, granuloma, even chronic poisoning. Due to its unique physical and chemical properties, mercury beads can be difficult to retrieve, especially in the eyes. Most previous studies have focused only on the rigid orbital foreign bodies rather than the injuries related to liquid heavy metal and their extraction method.

Methods: We reported a case of thermometer-related orbital injuries in a 4-year-old boy. To better locate, visualize and remove the mercury beads without complications, a Digital Subtraction Angiography (DSA)-guided, methylene blue marked access was taken, followed by further removal of scattered tiny mercury droplets with an adapted aspirator.

Result: At least 0.7411g mercury was taken out during the surgery. After a four-year follow-up, the boy had no residual symptoms, with his urine mercury decreased gradually.

Conclusion: Assessing the risk-return coefficient and making an appropriate therapeutic plan is an integral part of the pursuit of therapeutic progress. With the guidance of DSA and methylene blue, the suction of the reformative aspirator, we finally locate the mercury beads, maximize the removal of beads, reduce the length and depth of incisions, and keep the essential structures intact. Hence, we found it a valuable surgical skill on such occasions, worth sharing for future references.

Background

Mercury is a widely used poisonous heavy metal. Mercury toxicity may occur in our daily life, especially in young children. Acute or chronic mercury poisoning will damage the respiratory, nervous, and cardiovascular systems, which is well-reported in the literature[1, 2]. We herein report a case of chronic mercury poisoning caused by retained intraorbital mercury beads after traumatic implantation and our method of positioning and removal of intraorbital mercury beads, which to the best of our knowledge, has not been reported yet.

Case Presentation

A 4-year-old boy presented with retained intraorbital mercury after fell on a mercury thermometer 21 days ago. He suffered from emotional irritation, amnesia, and insomnia. Mild tremors and muscle twitching were found in his hands and feet. He is uncooperative in the physical examination. A 3mm×1mm healed wound was spotted in his left superio-nasal eyelid (Fig. 1a, white arrow). The boy was otherwise healthy, with no other remarkable history.

The boy's urine mercury was high (11.6 ug/g urine creatinine compared to reference level <4 ug/g urine creatinine); urinary protein and retinol-binding protein (RBP) were positive; 24 hours urinary output was 200mL, which may indicate the renal impairment. The computed tomography (CT) scan and X-ray revealed a nebula-like distribution of multiple mercury droplets surrounding a broken tip of the thermometer near the trochlear ganglion (Fig. 1b, 1c).

After joint consultation of ophthalmologist, neurologist, interventional radiologist, and pediatrician, we proposed a minimally invasive DSA-guided, methylene blue marked surgical access and got the patient's guardians informed consent by simulating surgery in the wet lab with them.

The child was lying supine in a DSA bed under general anesthesia. The precise position of the mercury beads was located by adjusting a 25-gauge, 1.5-inch syringe needle pointing to the largest piece of mercury under X-ray on a DSA device (Fig 2a). Then, methylene blue dye in the syringe was injected little by little while withdrawing the needle to mark the surgical route (Fig 2b), followed by a 2cm-incision along the path of stained tissue, followed by smoothly positioning and removal of the broken tip of the thermometer. Furthermore, with the whitish orbital tissue stained blue, the residual silvery mercury beads can be better visualized. Residual mercury droplets were further aspirated with a suction tube adapted with a sterile 1ml pipette tip (Fig. 2c, 2d). Copious irrigation was used before the wound closure. By this procedure, we took out 0.7411g (>70% by weight) of the retained intraorbital mercury, yet some tiny droplets are still trapped here (Fig. 3). Considering the smaller droplets may be enclosed in the tissue space, therapy with the chelating agent was continued to ensure complete mercury removal.

After a two-month follow-up, the boy's urine mercury was found to fluctuate between 50 and 85ug/g urine creatinine (compare). And four years later, the boy had no residual symptoms, with his urine mercury decreased gradually.

Discussion And Conclusion

This study was approved and monitored by the Clinical Research Ethics Committee of Second Xiangya Hospital of Central South University and adhered to the tenets of the Declaration of Helsinki. A statement on written informed consent was obtained from the patient's guardians after we explained the nature and possible consequences of the study.

We present a case of multiple intraocular metallic mercury foreign bodies. Chances of trauma-introduced mercury foreign body are not uncommon; there are also sporadic cases of eye injuries. However, to the best of our knowledge, the report of residual mercury beads in orbit and our removal strategy have not been published yet.

Orbital trauma is one of the primary reasons for monocular blindness worldwide. The formulation, size, and route of entry of an intraorbital foreign body may substantially impact the difficulty of treatment[3]. Accordingly, assessing the risk-return coefficient and making an appropriate therapeutic plan is an integral part of the pursuit of therapeutic progress.

Callahan et al.[4] reported the incidence rate of intraorbital foreign bodies ranges from 2.9% to 16%. Due to its different physicochemical properties, the intraorbital foreign bodies can be classified into nonmetallic, metallic, and organic substances[5]. In general, an inert, well-tolerated, and deeply seated metal would be managed conservatively[6]. Nevertheless, organic objects like woods may be oxidized and degraded gradually, triggering a severe inflammatory response[7]. At the same time, some unique metals like iron, copper, and mercury may cause a series of complications, such as siderous bulbi, ocular chalcosis, systemic poisoning, etc., which also need to be addressed.

Metallic mercury is a widely used poisonous heavy metal, commonly found in thermometers, manometers, fluorescent light bulbs, cosmetics, dental amalgam, etc.[2] Since its silver-white appearance is attractive, metallic mercury leaks have become a common hazard to children, especially those under the age of four[8]. By inhibiting the sulphydryl, mercury sources disrupt the proteins, causing cell dysfunctions irreversibly[1, 9]. Besides that, the severity of mercury poisoning also depends on its form and entry path to the organism (Table 1).

Inhalation is the most common exposure route for elemental mercury spills[2, 10]. In addition to causing acute pulmonary disease by inhaling massive mercury vapor, neurological and renal disorders are usually triggered by long-term exposure[1]. Gastrointestinal ingestion is a rare way for mercury poisoning. Still, when observed, it is often associated with delayed gastric emptying, diverticulosis, and fistulas, accelerate gut flora converted metallic mercury into organic compounds, which tend to be much more toxic[11, 12]. Apart from that, large dosages may still lead to hepatic dysfunction with jaundice developed[12]. Although local injection of mercury is usually of no consequence to the state of health, mercury residue always leads to contact dermatitis, granuloma, ischemia, and gangrene[13-17]. There are also some apparent systemic effects after intravenous injection, like pulmonic embolism and embolization of the heart[13, 18, 19]. Beyond that, Jin Yan et al.[20] have documented two cases of secondary hypertension as the primary clinical manifestation of chronic contact mercury poisoning. And there are also a few cases of hemorrhagic colitis secondary to inhalation[21, 22].

Our case had posed special challenges on management due to several reasons:

Firstly, because of the high specific gravity, surface tension, and liquid form, mercury couldn't be sucked out easily. What's worse, the larger mercury beads may be dispersed into many smaller ones and incarcerated into the deep tissue or, even worse, drop to the orbital apex, causing toxicity to the optic nerve. Secondly, 21 days passed after the failed attempt to take mercury beads out during the first debridement and suture surgery, and those foreign bodies might be trapped with organization and scar tissues. Thirdly, they are located deep inside the orbit, near the trochlear ganglion, which means limited access and visibility with a high risk of iatrogenic injury to the critical structures nearby.

In the published literature, the reported way for removing intraorbital foreign bodies includes open local tissue resection[23], magnetic pull[24], suction via an elastic needle[25], sonographic guidance[26], minimally invasive endoscopic surgery[27], computer-assisted image-guided 3-dimensional surgical navigation[28]. Metallic mercury does not have any magnetic properties. A conventional surgery with sonographic guidance may not be accurate enough, resulting in bigger facial scars. Moreover, small, trapped, and deeply seated foreign bodies are challenging for minimally invasive endoscopic surgery on account of loss of hemostasis and nerve injuries. Therefore, in our case, we need a safe, precise, and minimally invasive strategy for a better structural, functional, and cosmetic prognosis. By the conditions we have, with the guidance of DSA and methylene blue, and the suction of reformative aspirator, we finally locate the mercury beads, maximize the removal of beads, reduce the length and depth of incisions, and keep the essential structures intact.

This set of skills enable us successfully removed the majority(>70%) of the scattered mercury in our case, and during a 4-year follow-up, the patient is healthy and free of mercury poisoning manifestations. Hence, we found it a valuable surgical skill on such occasions, worth sharing for future references.

Declarations

Ethics approval and consent to participate

A statement on written informed consent was obtained from the patient's guardians after we explained the nature and possible consequences of the study. This study was approved and monitored by the Clinical Research Ethics Committee of Second Xiangya Hospital of Central South University.

Consent for publication

Written informed consent for publication of the images, data, and video in this study was obtained from the patient's legal guardians.

Availability of data and material

Our data and materials are available from the corresponding author's email: yun.li@csu.edu.cn.

Competing interests

All the authors declare that there are no competing interests.

Authors' contributions

XW and YL brought up the idea and performed the surgery; YL, XW, HZ, and BC collected the clinical data; YC and YL drafted the manuscript; YC performed and summarized the literature review. All authors have read and approved this manuscript.

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Tables

Table 1 The clinical symptoms and treatments of metallic mercury poisoning

Organs	Forms	Complications	Treatments
Pulmonary	Inhalation	Acute inhalation: Respiratory system (Cough, dyspnea, chest pain, pulmonary edema); Alimentary System (gingivitis, metallic taste, nausea, vomiting, anorexia, diarrhea, hemorrhagic colitis); Nervous System (cognitive, personality, sensory, and motor disturbances); Cardiovascular system (arrhythmia, hypertension); Chronic inhalation: Nervous System (headaches, ataxia, insomnia, irritability, fatigue, tremors, paresthesia, impaired cognitive skills); Urogenital system(Tubular dysfunction, dysuria)	Get rid of toxic environment, symptomatic and supportive treatment (nutrition support, protect kidney function, neurotrophic therapy, anti-infective therapy...) chelating therapy
Gastrointestinal	Ingestion	Long-term existence may lead to systemic toxicity	Gastrointestinal lavage, cathartic, activated carbon, chelating therapy
Intramuscular/ Articular	Implantation	Hyperemia, swelling, effusion, local pain, limited range of motion, granulomas tissue formation, aseptic abscess	Surgical treatment, chelating therapy
Subcutaneous	Implantation	Severe soft tissue reaction, local abscess, granuloma formation, necrosis	Surgical treatment, chelating therapy
Intravenous	Injection	Ischemia, gangrene, pulmonic embolism, pulmonary empyema, embolization to the heart	Plasma displacement, hemodialysis
Eye	Implantation	Impaired vision, uveitis, endophthalmitis, acute retinal necrosis, retinal detachment	Surgical treatment, chelating therapy

Figures

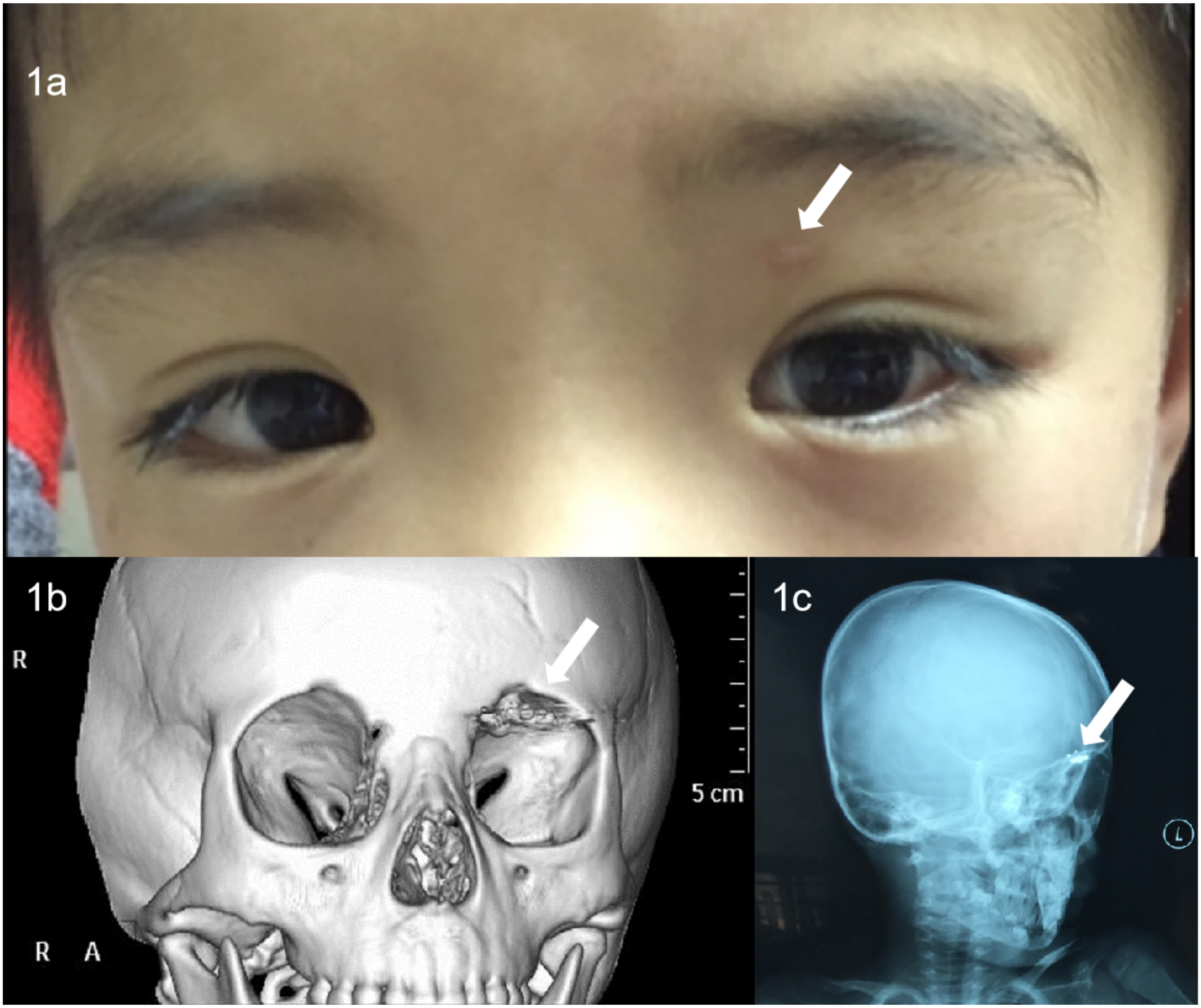

Figure 1

The preoperative wound of the patient (a), CT and X-ray of the patient's head showing multiple radiopaque particles in the superio-nasal orbit (b, c).

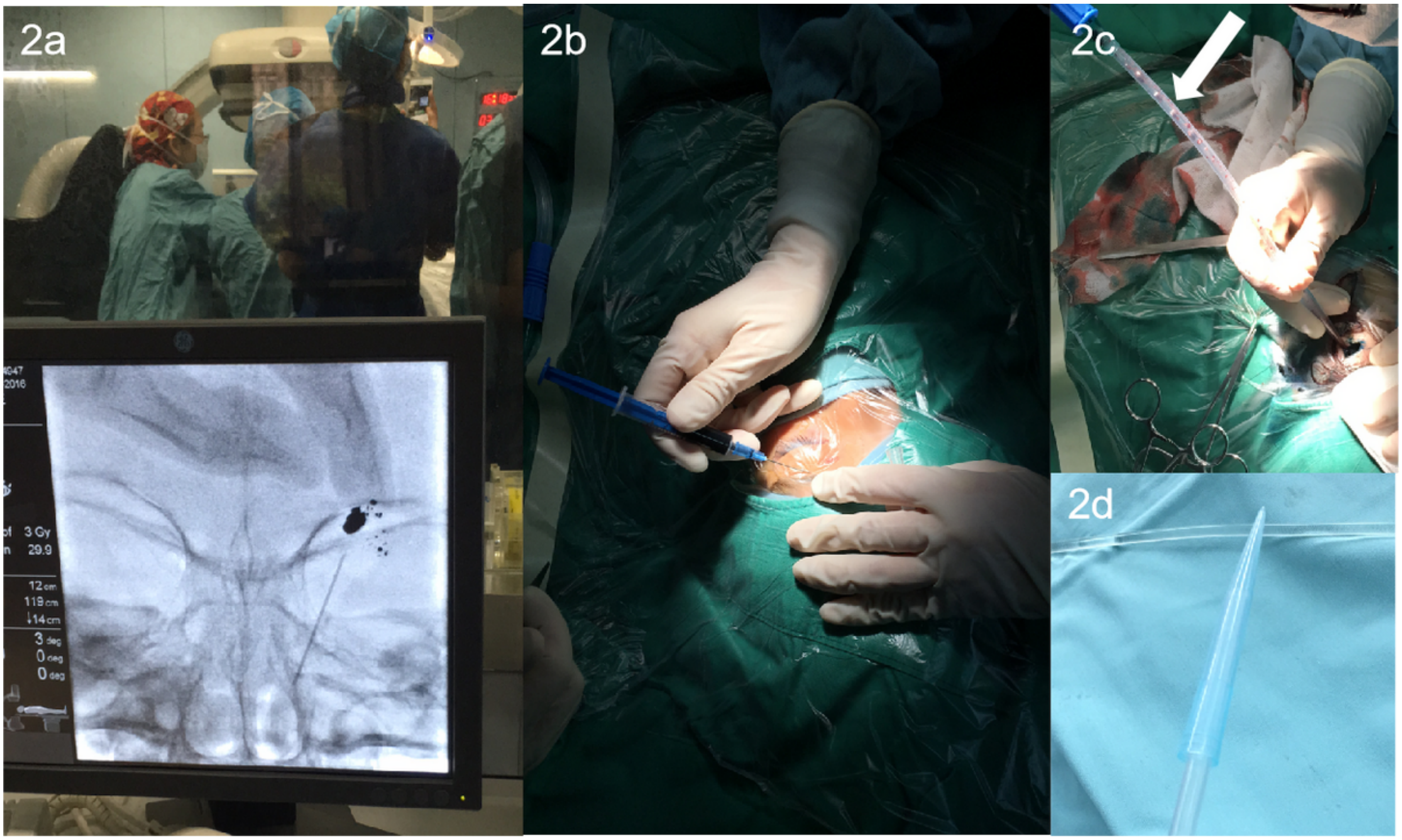

Figure 2

the procedure was carried out on a DSA bed, with radiologist monitoring the positioning image and ophthalmologists doing the surgery(a); A 25-gauge, 1.5-inch syringe needle attaching methylene blue dye was applied for 1. incision route marking, and 2. increasing visualization of mercury beads (b); The tiny mercury beads we took out (c), and a sterile pipette tip adapted was used for suction (d).

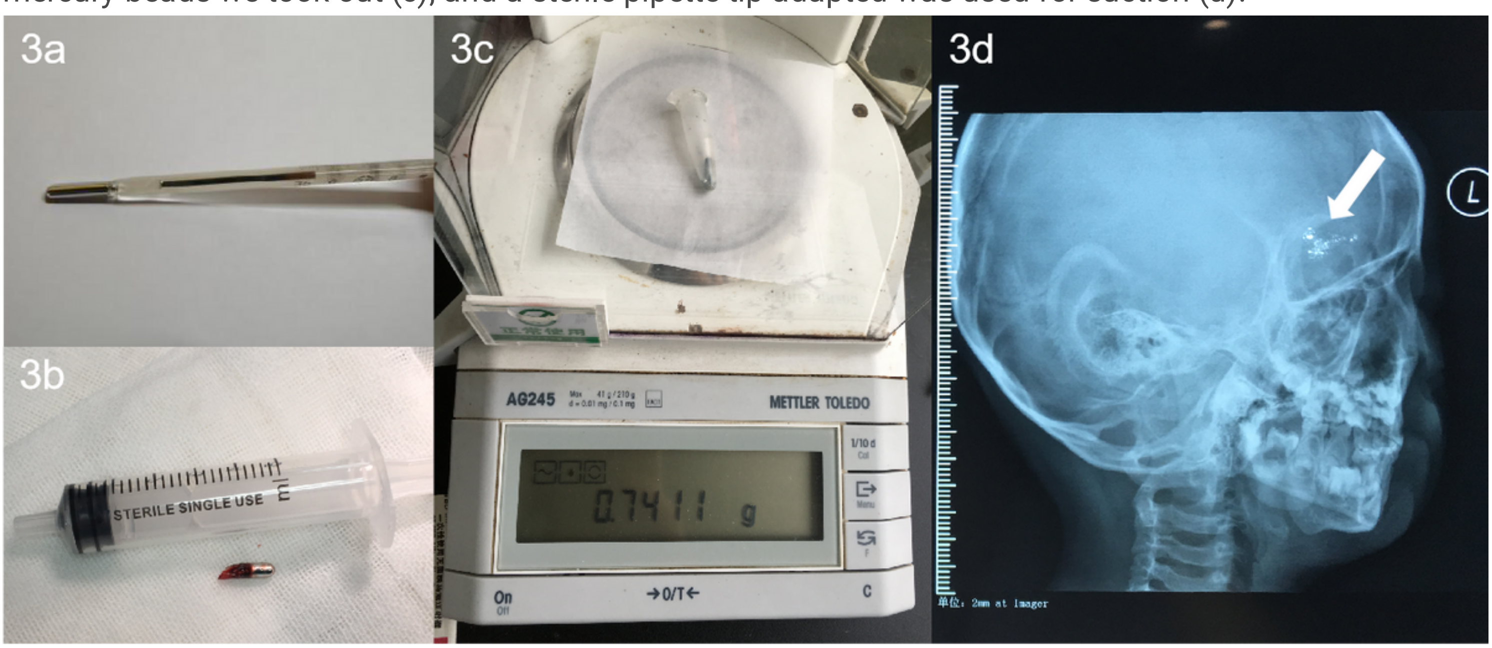

Figure 3

Image of the same type of mercury thermometer in this case, with a total mercury weight of 1.0g (a); the broken end removed from the orbit (b), and the mercury beads we took from the boy weighing 0.7411g (c); A postoperative X-ray showed small amounts of droplets are still trapped in the superio-nasal orbit (d).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SurgeryVideo2.mp4