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Case Report

# Middle Ear Welding Injury: Case Report and Literature Review

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Damage to the middle ear (ME) caused by penetrating welding sparks can lead to a variety of adverse outcomes. An exhaustive review of the literature is lacking, particularly with regard to clinical presentation, diagnostic-therapeutic work-up, and outcomes. Here we describe the clinical details of an injury caused by the largest welding foreign body ever reported in the ME. In addition, we present a comprehensive review of the relevant literature.

**KEYWORDS:** Welding injury, middle ear, foreign body, external auditory canal, tympanic perforation

## INTRODUCTION

Middle ear (ME) injuries due to foreign metal bodies are rare but can have serious consequences. Among the possible causative mechanisms, welding accidents have been reported. Indeed, if ear protection is inadequate, metallic sparks can pass through the external auditory canal (EAC) and enter the ME. Damage to ME structures is caused not only by the violent penetration of the welding beads but also by their high temperatures, which can reach up to 1000°C.[1] In addition to this, the metal slags behave like foreign bodies, causing an inflammatory reaction.[2] This can lead to a number of consequences, including persistent tympanic membrane (TM) perforation, chronic otitis media, otorrhea, ossicular chain disruption, facial nerve injury, taste alteration, peripheral vestibular dysfunction, hearing loss, and tinnitus. Here, we describe our experience and provide a synthesis of the existing data on the subject. The clinical presentation, investigations, and management of our case are discussed in comparison with the literature (see Appendix Table 1).

## CASE PRESENTATION

A 20-year-old welder was injured at work when a piece of glowing molten metal fell into his right ear. He presented to the emergency department 2 hours after the accident complaining of right otalgia and hearing loss. A skull x-ray showed an elongated metallic foreign body situated in the right ME. He was immediately referred to our ear, nose, and throat (ENT) department (Figure 1). Otoscopic examination revealed inflammation and burned skin in the EAC. An anterior perforation of the TM with inflamed mucosa and otorrhea was visible. The splinter was partially recognizable in the protympanum but could not be removed due to the phlogosis and the protrusion of the anterior wall of the EAC (Figure 2). There was no evidence of vestibular damage on bedside examination. There was no facial nerve dysfunction. Audiometry revealed a moderate conductive hearing loss with preservation of bone conduction (Figure 3). Both systemic and topical antibiotic-steroid therapy were administered. On the same day, the patient underwent a petrous computed tomography (CT) scan (Figure 4). Examination confirmed the presence of an elongated foreign body of metallic density (approximately 7 mm long) located in the tympanic cavity. The distal portion of the splinter was lodged in the Eustachian tube (ET). Twelve days after the trauma, the patient underwent surgical exploration for ME. The inflammation was reduced but still present. The perforation had enlarged since the previous inspection: the pars tensa was completely absent along with the anterior fibrous annulus. The ossicular chain was intact, but the malleus was medialized. A retroauricular approach was made and the fascia of the temporal muscle was harvested. An anterior canaloplasty was performed, after which a safe removal was possible.

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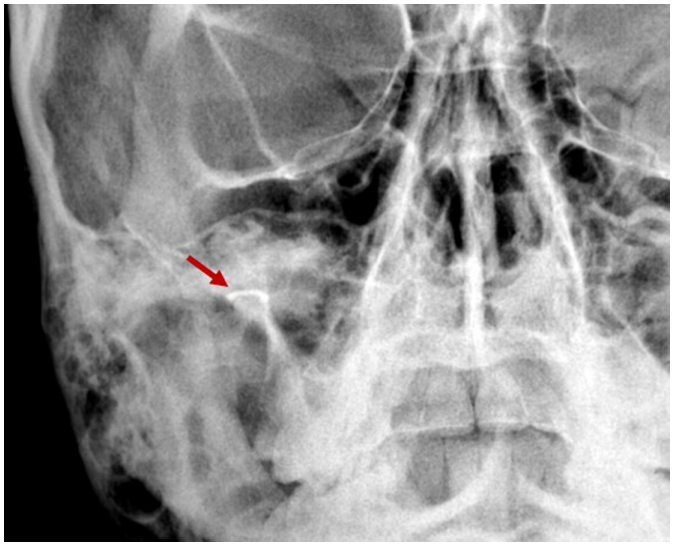

**Figure 1.** X-ray: arrow indicating the welding splinter.

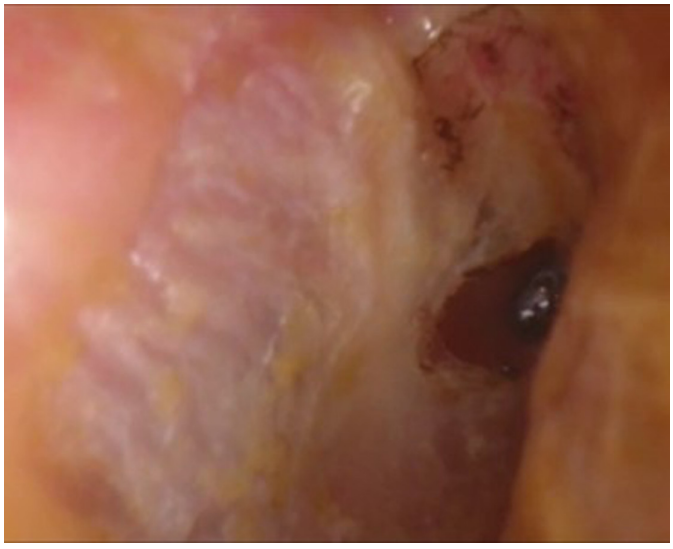

**Figure 2.** Preoperative otoendoscopic view.

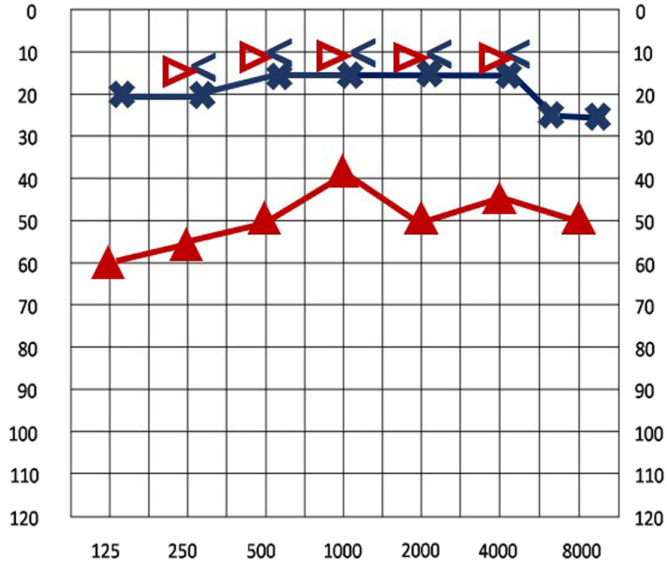


**Figure 3.** Preoperative pure tone audiogram.

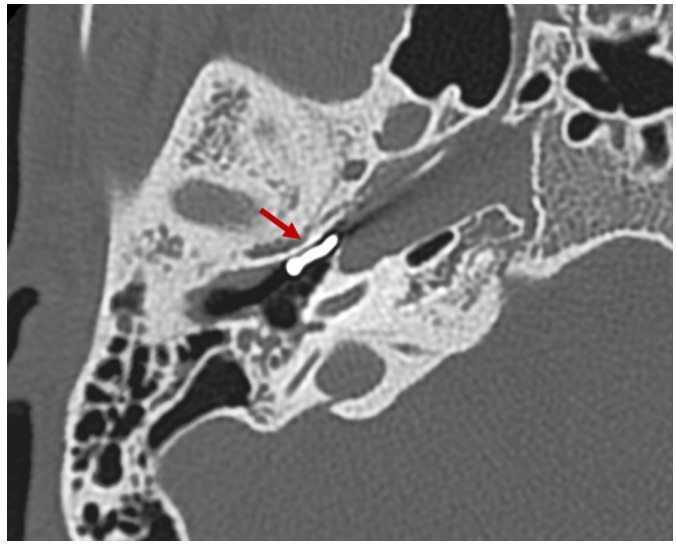

**Figure 4.** CT scan: arrow indicating the welding splinter located in the tympanic cavity, with the distal portion lodged in the Eustachian tube in contact with the belly of the tensor tympani and in close proximity to the anterior wall of the ipsilateral carotid canal. In addition, the upper edge of the welding splinter was adjacent to the second part of the facial bony canal.

Immediate TM reconstruction was carried out with an overlay myringoplasty. A dermoepidermal graft taken from the retroauricular skin was placed anteriorly to stabilize the temporal fascia and cover the EAC bone. The postoperative course was uncomplicated and the patient returned to his normal activities 2 weeks later. One year later, the eardrum was intact although slightly retracted and the pure-tone audiogram showed a mild conductive hearing loss (Figures 5 and 6). The patient gave informed consent for his details to be published.

## DISCUSSION

In recent decades, ME welding injuries have been reported relatively frequently in the international literature. Unfortunately, to our knowledge, only 7 English-language studies are available in full text.

**Figure 5.** Postoperative otoendoscopic view.

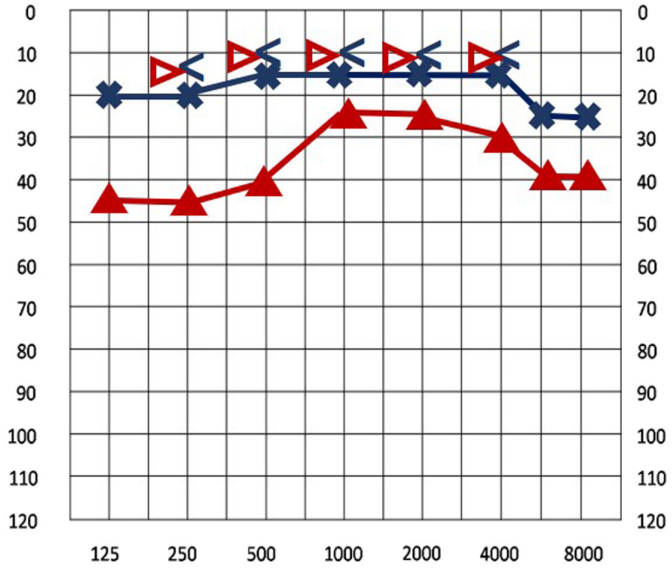


**Figure 6.** Postoperative pure tone audiogram.

Furthermore, only 6 of these reported a detailed analysis of clinical cases (see Additional Material). As a result, relevant data on the management and outcomes of ME welding injuries are puzzling. In light of this, we aimed to conduct a comprehensive review of the existing literature on this topic. In addition, we described the largest metal foreign body ever reported to have been found in the ME of a welder. Indeed, a peculiarity of our case is the size of the splinter, which was 7 mm long. Whereas other authors reported the largest bear to be 3 mm in size.[3]

In all the cases for which we have complete information, except for the case described by Simons et al,[2] the first assessment took place a short time after trauma.[1,3-6] In all cases where we have a full report, patients presented with a perforated membrane.[1-6] The audiological counterpart in terms of conductive hearing loss is mentioned in 3 papers.[3,4,6] Inner ear (IE) damage was reported in 4 articles.[3,5,7,8] The IE trauma manifested clinically as sensorineural hearing loss to anacusis, tinnitus and vertigo, often declared irreversible. Apart from Hervochon and colleagues, who suspected a perilymphatic fistula, other authors have not described the possible mechanisms of injury. We can speculate that a labyrinthine concussion may be involved.[9] A total of 4 patients were reported to have facial palsy with or without dysgeusia at their presentation,[3,5,8,10] and one had isolated dysgeusia.[4] Another potentially threatening aspect is the proximity to the internal carotid artery (ICA).[3] In the case reported by Scagnelli et al[1] the slag abutted the ICA, and angiography was required before and after the surgical removal to ensure the integrity of the ICA.[1]

In a high percentage of cases, a CT scan was mentioned in the diagnostic work-up.[1,3-6,11] Depending on the clinic and the patient's management pathway, multiple CT scans or other instrumental investigations were performed.

Treatment included at least one surgical procedure in 5 of the previous comprehensive reports.[1,3-6] Even in articles for which we do not have complete information, surgical treatment is widely documented.[7,11-14] Panosian et al[3] reported only medical management in a young welder who was found to have no foreign body in the ME on examination. Considering the patients who underwent surgery, TM reconstruction was performed in the majority of the cases. Leedman and Kuthubutheen, as well as we, opted for ME exploration and TM reconstruction in a single stage.[4] On the other hand, Eleftheriadou et al[6] and Scagnelli et al[1] used staged TM reconstruction. Hervochon and colleagues performed 3 procedures: an immediate ME exploration, an intermediate canaloplasty to prevent secondary stenosies, and finally facial nerve and auditory rehabilitation.[5]

The timing of surgery varies widely among authors from immediate exploration on the evening of the trauma[5] to 11 weeks later.[4] Reasons for choosing the timing and eventual staging of the procedure are not systematically identified. We can assume that they have been adapted to individual clinical conditions and organizational needs. Our patient was operated on 12 days after the accident. In fact, we believe that this timing is an adequate compromise between resolving the acute inflammation and avoiding chronic foreign body reactions. Moreover, according to Vartiainen and Nuutinen, incandescent welding splinters cause a cauterizing effect which damage ME tissues vascularity.[15] This could be the reason why we found an increase in the size of the perforation at the time of surgery. Intraoperatively, we found that the inflammation was not such as to compromise the membrane graft, so we proceeded with the myringoplasty at the same stage.

Functional outcomes are heterogeneous and difficult to compare. Looking at complete case reports, including our own, all cases that underwent reconstructive surgery achieved anatomical and audiological success.[1,4-6] On the other hand, in the case series for which we have partial data, the results are less encouraging.[7,8,12,15] In general, Vartiainen and Nuutinen claim that welding injuries heal less successfully than other perforations due to the loss of tissue vascularity. The resulting ME scars are thought to cause graft rejection.[15] In our opinion, the retraction in our patient's TM is to be attributed to tubal dysfunction due to scarring stenosis by the above mechanism.

We believe that management strategies and expected functional outcomes depend on many factors, including preoperative status. Patients and clinicians should be aware of the heterogeneity of possible clinical presentations, which requires individualized management strategies. In this regard, we invite colleagues to share their experiences on this topic. This would corroborate the existing data and contribute to an exhaustive overview of the kaleidoscopic aspects of ME welding injuries.

**Informed Consent:** Verbal informed consent was obtained from the patients/patient who agreed to take part in the study.

**Peer-review:** Externally peer-reviewed.

**Author Contributions:** Concept – G.B., E.C., S.P.; Design – G.B., E.C.; Supervision – S.P.; Materials – E.F., F.B.; Data Collection and/or Processing – A.L., W.L., N.N.; Analysis and/or Interpretation – G.B.; Literature Search – G.B., E.C.; Writing – G.B., E.C.; Critical Review – S.P.

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**Appendix Table 1. Middle Ear Welding Injuries**

| Year | Authors | Cases | Gender, age | Evaluation time | Clinical details | Audiovestibular presentation | Dimensions, Location | Investigations | Treatment | Surgery time | Outcomes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | Frenkiel S, Alberti PW. | 11 | N/A | N/A | N/A | N/A | N/A | N/A | 8 TPL, 3 N/A | N/A | 2 success, 9 N/A |
| 1979 | Jarzebski J. | 19 | N/A | N/A | N/A | N/A | N/A | N/A | Conservative procedures+ 5 TPL | N/A | N/A |
| 1986 | Stage J, Vinding T. | 1 | N/A | N/A | FN palsy | IE damage with deafness | N/A | N/A | N/A | N/A | FN palsy, N/A |
| 1991 | Fisher EW, Gardiner Q. | 5 | N/A | N/A | from minor burns to TM perforation | N/A | N/A | N/A | MPL for TM perforations | N/A | N/A |
| 1991 | Mertens J, et al. | 25 | N/A | N/A | N/A | 12% IE traumatization | N/A | N/A | Conservative therapy/ immediate and interval operation/ secondary seal by TPL | N/A | 4% remaining HL |
| 1993 | Panosian MS, et al.* | 1 | M 35 yrs | few hours | TM perforation, EAC skin excoriated, complete FN palsy, decreased taste sensation | Vertigo, tinnitus, profound ipsilateral SNHL | 3 mm, anteriorly at the ET orifice and adjacent to the ICA | X ray, CT scan, Hilger FN stimulator | Systemic steroids, antibiotic drops, facial nerve and ME exploration, CROS HA | at least 6 days | dry TM perforation, HL unchanged from preoperative, grade III FN palsy |
| 1993 | Panosian MS, et al.* | **1** | M 18 yrs | 3 days<br>2 weeks | TM perforation, grade II-III FN palsy, numbness of the right side of his tongue<br>TM perforation, otorrhea, resolution of facial palsy | Mild low-frequences CHL | no wb noted | N/A | systemic steroids, ear drops | / | dry TM perforation, mild CHL |
| 1993 | Vartiainen E, Nuutinen J. | 9 | N/A | N/A | N/A | N/A | N/A | N/A | 9 MPL | | 5 intact TM, 4 perforated TM |
| 1994 | Panosian MS, Dutcher PO Jr. | (2) | N/A | N/A | (2 FN palsy) | (1 deafness) | N/A | N/A | N/A | N/A | N/A |
| 2007 | Eleftheriadou A et al. | 1 | M 36 yrs | immediate<br>3 mo<br>6 mo | TM shrunken and thickened with perforation | CHL | 2.2 mm, around the ossicles | CT scan | Exploration of the ME for wb removal<br>OPL+TPL | Time N/A<br>4 weeks | TM intact and normal hearing |
| 2009 | Keogh IJ, Portmann D. | 1 | N/A | N/A | Chronic middle ear inflammation, otorrhea and TM perforation | N/A | N/A | CT scan | MPL | N/A | N/A |
| 2016 | Simons JP et al. | 1 | M<br>76 yrs | N/A | TM perforation, 2wb on the promontory, partially covered with mucosa | no CHL | N/A, 2 wbs on the promontory | No | N/A | / | N/A |
| 2021 | Leedman SR, Kuthubutheen J. | 1 | M<br>60 yrs | Immediate<br>8 weeks | TM perforation, dysgeusia | mild CHL | 1.7 mm, into the sinus tympani and abutting the RW membrane | 2 CT scan | Endaural approach+ posterior CPL, MPL | 11 weeks | TM intact, no SNHL, no imbalance, minor dysgeusia |

(*Continued*)

**Appendix Table 1. Middle Ear Welding Injuries (*Continued*)**

| Year | Authors | Cases | Gender, age | Evaluation time | Clinical details | Audiovestibular presentation | Dimensions, Location | Investigations | Treatment | Surgery time | Outcomes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2023 | Hervochon R et al. | 1 | M<br>48 yrs | Immediate | TM perforation, inflammation and burning of the skin of the EAC and TM, presence of wb FN palsy (grade VI) | left anacusis and complete vestibular areflexia | N/A, tympanic cavity | 2 CT scan VHIT, EMG, ME exploration | ME exploration (wb removal, RW and OW sealed to treat perilymphatic fistula) calibration of the EAC+ iv steroids and antibiotics+ vestibular physiotherapy, CROS hearing aid<br>Facio-facial anastomosis + CI+ SP+ intensive facial and auditory re-education | the evening<br>1mo<br>9 mo | hearing restored with SDS of 100%, grade III FN palsy |
| 2023 | Scagnelli R et al. | 1 | M<br>56 yrs | 30 yrs before | TM perforation | N/A | N/A, within the ET abutting the ICA | CT scan, angiography | Combined transnasal+ transtympanic approach for wb removal<br>TM reconstruction | Time<br>N/A<br>3mo | N/A |
| 2024 | Our case | 1 | M<br>20 yrs | 2 hours | TM perforation | Moderate CHL | 7 mm, distal portion into ET, upper edge was in contiguity with the II portion of FN | X-ray, CT scan | ME exploration+ anterior canaloplasty+ MPL | 12 days | TM intact, mild CHL |

CHL, conductive hearing loss; CI, cochlear implantation; CROS, contralateral routing of hearing sounds; CT, computed tomography; EMG, electromyography; ET, Eustachian tube; HA, hearing aid; HL, hearing loss; ICA, internal carotid artery; IE, inner ear; MPL, myringoplasty; mo, months; N/A, not assessed; OPL, ossiculoplasty; SNHL, sensorineural hearing loss; SP, subtotal petrosectomy; TPL, tympanoplasty; TM, tympanic membrane; wb, welding bead; yrs, years. *the same article. In bold: available full test articles. In brackets: duplicated cases (same authors).