A Rare Case of Dermatitis Caused by Hypersensitivity to Orthopedic Synthetic Implant

ABSTRACT

Aims: The present case report aims to describe a rare case of hypersensitivity to orthopedic synthetic materials, an adverse event that developed following surgical intervention for the correction of an open fracture of the radius and proximal ulna.
Presentation of Case:A 63-year-old woman sustained an open fracture of the right olecranon, requiring multiple surgeries, including external fixation and osteosynthesis. Postoperative complications included recurrent infectionsand persistent chronic dermatitis. A Patch Test identified allergies to cobalt chloride, nickel sulfate, and formaldehyde resin, potentially linked to the orthopedic implant. Afterthe external fixator was removed, there wasa gradual improvement of the skin lesions and pruritus.
Discussion: Hypersensitivity reactions to metal orthopedic implants, though rare, can cause cutaneous and extracutaneous symptoms, including eczema, urticaria, and implant complications. Diagnosis relies on patch testing. Treatment includes allergen removal, local therapy for mild cases, or systemic corticosteroids for severe symptoms.
Conclusion: Stainless-steel prostheses are common in osteosynthesis but can rarely cause hypersensitivity due to metal ion release from biomechanical stress.This case underscores the need for preoperative allergy screening and highlights the importance of developing implant materials that minimize hypersensitivity risks

Keywords: *Allergic Contact;Dermatitis; Delayed; External Fixators;Hypersensitivity.*

1. INTRODUCTION

Metallic implants are commonly used in surgical treatments, particularly in orthopedics, and although rare, they can be associated with complex adverse reactions(Pacheco, 2018). One example of the use of these materials is in the treatment of olecranon fractures, which account for 10% of all upper extremity fractures and have a higher incidence in women aged 65 years or older due to the increased risk of osteoporosis(Brolin & Throckmorton, 2015).To prevent certain complications, surgical intervention on the traumatic elbow should be performed within 24 hours after the initial injury. This procedure is necessary due to the classification of the elbow as a complex joint and the narrow margin for error when dealing with traumatic injuries to the proximal ulna and radius (Rafi & Tiwari, 2022).

In this context, external fixation using instruments made of stainless-steel alloy, composed of chromium, nickel, cobalt, and molybdenum, represents the orthopedic synthetic material commonly used in Brazil today, particularly as an emergency countermeasure. However, it is not the best option for elderly patients as it relies on ligamentotaxis and cannot achieve anatomic reduction of specific fragments (Medda *et al*, 2021). Nonetheless, external fixation is valuable for its rapid initiation of osteosynthesis (Chhabra & Yildirim, 2021).

In summary, the ideal treatment approach depends on individual characteristics, and the choice of a fixation method must be thoroughly evaluated by the surgeon, taking patient-related variations into account. In this regard, different forms of external fixation provide adequate stabilization, as well as satisfactory radiological and functional outcomes for managing fractures of the radius or ulna of varying severity (Ermutlu*et al*, 2020).

One of the adverse reactions with low incidence is an allergic reaction to the metallic composition of the fixator, whether internal or external. This allergic reaction, specifically allergic contact dermatitis (ACD), is a type IV hypersensitivity response, accounting for 20% of contact dermatoses. ACD is diagnosed with a gold-standard patch test to confirm the diagnosis in patients with persistent symptoms. Acute ACD typically presents as eczematous erythema, or vesicular dermatitis. Although ACD may manifest as a localized and well-demarcated skin rash, most commonly on the hands or face, it can also be more widespread (Murphy *et al*, 2023).

The present case report aims to describe a rare case of hypersensitivity to orthopedic synthetic materials, an adverse event that developed following surgical intervention for the correction of an open fracture of the radius and proximal ulna.

2. PRESENTATION OF CASE

A 63-year-old female patient, with no history of osteoporosis, sustained trauma to the right elbow following a fall from standing height, resulting in an open olecranon fracture. A routine presurgical workup was done, and she underwent emergency surgery for the placement of an external fixator on the right upper limb, along with osteosynthesis of the distal third of the right ulna, using a plate and implantable pins. In the postoperative period, she developed edema, hyperemia, and local warmth, raising suspicion of cellulitis. Clinical improvement was observed, and she was discharged with a prescription for antibiotics and analgesics.

One week after discharge, she was readmitted due to cellulitis associated with purulent discharge. The external fixator was removed, leaving only the plate used for osteosynthesis, as shown in the X-ray in Figure 1. Immobilization was then achieved using a right axillopalmar splint and treatment with ciprofloxacin and clindamycin was initiated for 7 days. Computed tomography revealed a comminuted epiphyseal fracture of the distal radius and ulna, dislocation, and avulsion of the right radial head. On postoperative day 15, a new surgery was planned for the osteosynthesis of the epiphyseal fractures.

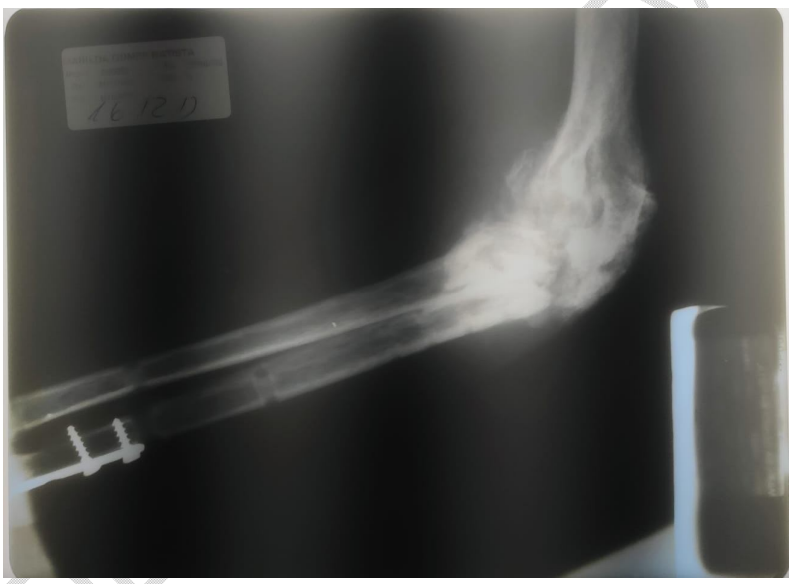

Figure 1: X-Ray of right elbow.
Source: Personal collection

However, the procedure was postponed due to leukocytosis (14,040/mm³). The axillopalmar splint was maintained, and Augmentin (amoxicillin / clavulanate) was prescribed for 7 days. After normalization of leukocyte counts (6,410/mm³), the patient underwent osteosynthesis with fixation of the olecranon using a plate and Kirschner wires.

At the 1-week postoperative follow-up, serous discharge from the surgical wound was noted, and ciprofloxacin was prescribed for an additional 7 days. The patient developed persistent serous discharge at the base of the Kirschner wires, without apparent additional signs of infection, leading to wire removal.

One week later, she presented to the emergency department with persistent signs of infection at the surgical site, laboratory tests showed a CRP= 153,6mg/dL. A nosocomial

infection was suspected, and vancomycin and meropenem were prescribed. Mechanical-surgical debridement and placement of a transarticular external fixator on the right elbow were performed.

The patient also developed severe and diffuse pruritus, raising suspicion of drug-induced dermatitis secondary to prolonged antibiotic use. A histopathological examination revealed a moderate lymphohistiocytic inflammatory infiltrate with morphological findings of mixed dermatitis, consistent with suspected drug-induced dermatitis. However, after evaluation by the internal medicine and infectious diseases teams, this diagnosis was ruled out. A subsequent surgery was performed to remove the olecranon plate, suspected to be the source of infection. Postoperatively, an eczematous, desquamative, and pruritic lesionpersisted, as seen in Figure 2, leading to admission to the intensive care unit (ICU) for investigation of osteomyelitis, which was later ruled out by computed tomography.

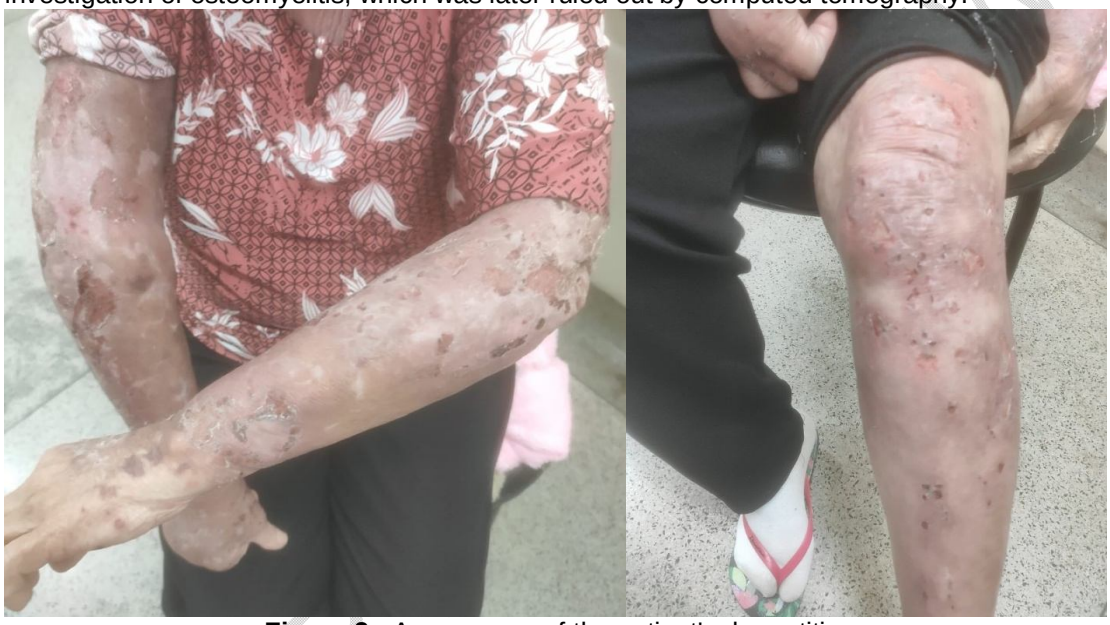

Figure 2 - Appearance of the patient's dermatitis
Source: Personal collection

Given the persistence of chronic dermatitis, patch testing with PATCHKIT STANDARD NEW GENERATIONS using the Finn Chambers technique (FDA Allergens) demonstrated positive reactions to cobalt chloride (associated with vitamin B12), nickel sulfate, and tosylamide/formaldehyde resin. Allergy to the metallic implant was considered, and replacement with a chromium and nickel-free prosthesis was recommended.

The external fixator was removed, resulting in gradual improvement of the skin lesions and pruritus. Physiotherapy and antihistamines were prescribed. Regarding the orthopedic outcome, the patient was followed on an outpatient basis, showing fracture consolidation of the right ulna, signs of bone resorption in the involved bones, and no further discharged. She was ultimately discharged from orthopedic follow-up.

3. DISCUSSION

The implantation of orthopedic devices is a common strategy in various surgical correction treatments (Thomas *et al*, 2024). However, despite being uncommon, there is growing concern about hypersensitivity reactions to implants (HRI), particularly to metals such as

nickel, cobalt, and chromium present in these devices. This can occur because such materials are exposed to fluids, biological tissues, and mechanical stresses, making them susceptible to corrosion and ion release, which triggers an immune response that can be characterized as an adverse event (Zemelka-Wiacek, 2022).

In the case of the patient described in this report, an external fixator was initially used to correct the fracture in the right upper limb. Subsequently, a plate and implantable pins were used for osteosynthesis, all of which were orthopedic materials made of stainless steel (a metallic alloy commonly used in orthopedic implants due to its chromium content, which provides greater resistance to corrosion, but also includes other components such as nickel, cobalt, and molybdenum) (Tapscott &Wottowa, 2024). However, despite the high purity of stainless steel, its inherent passive protective layer, and plasma spray coating, friction can still cause the steel to release soluble products into the body (Wozniak *et al*, 2021). According to studies, this may induce the expression of intercellular adhesion molecule-1 (ICAM-1) and cytokine activation, influencing the local environment and, in rarer cases, triggering hypersensitivity in patients, as observed in this case (Toro *et al*, 2020).

The incidence and prevalence of metal allergies to implanted implants can be influenced by various factors. However, they are difficult to determine, as the literature lacks prospective longitudinal studies with clear objective criteria and large cross-sectional studies addressing these questions (Wawrzynski et al., 2017). Nonetheless, some relevant findings have been demonstrated in studies, such as the greater sensitivity and development of hypersensitivity to nickel in female patients (a factor also observed in the present case, where the patient was reported to have nickel hypersensitivity), while male patients exhibit greater sensitivity to cobalt (Silverberg *et al*, 2024).

Hypersensitivity reactions to implants (HRIs) are generally classified as delayed-type allergies mediated by T lymphocytes (type IV reaction), characterized by increased inflammasome activation induced by metal ions or particles and heightened cytokine (IL-1B) formation (Baumann & Crist, 2020). Such symptoms and factors characteristic of type IV hypersensitivity reactions were observed in the patient described in this report. Although some studies propose prior exposure to metals at high concentrations as a diagnostic hypothesis for HRI, suggesting sensitization of dendritic cells that could predispose the patient to ACD (Sebastião *et al*, 2020), this was not reported by our patient, and this theory has yet to be proven. Therefore, the most widely accepted hypothesis is that the predisposition to metal hypersensitivity is multifactorial.

The primary clinical symptoms of hypersensitivity to metals include localized cutaneous reactions or systemic allergic dermatitis of an eczematous nature, which may occur over the implanted material. These symptoms can also be present as urticaria, blistering eruptions, erythema multiforme, and vasculitis. Additionally, extracutaneous complications associated with orthopedic implants, such as pain and swelling at the implant site, aseptic inflammation, and prosthetic loosening, are common (Gaillard-Campbell & Gross, 2024).

From a laboratory perspective, the most standardized diagnostic tools are the skin patch test, the leukocyte migration inhibition test (LMIT), and the lymphocyte transformation test (LTT), which are the most widely used tests for metal hypersensitivity (Dordunoo*et al*, 2020). The patch test is considered the gold standard for diagnosing metal hypersensitivity and is more commonly used in clinical settings due to its simplicity compared to in vitro tests. The LMIT assesses leukocyte migration inhibition, whereas the LTT evaluates the proliferation of lymphocytes activated by metal ions. Although the LTT is the preferred test, its clinical application is significantly constrained by its high cost and the need for a specialized laboratory (Li & Li, 2021).

For treatment, allergen removal is consistently the most effective approach for all types of hypersensitivity. However, if the patient presents with only mild eczema or less severe dermatitis, local dermatological treatment is generally preferred. When systemic allergic symptoms occur, the prescription of oral prednisolone is also indicated (Ramcharan *et al*, 2023).

4. CONCLUSION

The fixation of a stainless-steel prosthesis as a therapeutic solution aimed at improving osteosynthesis and the patient's mobility is contradicted by the potential for hypersensitivity reactions to implants (HRI) made of metals such as nickel, cobalt, and chromium. Although composed of high-purity stainless steel and coated with plasma spray to inhibit particle oxidation, the release of soluble products into the body is inevitable due to the constant and uninterrupted exposure to the individual's biomechanics.

The literature lacks longitudinal studies that classify the adverse reactions caused by these metallic materials in a way that addresses complications arising from implants used in surgical situations. Therefore, this case report seeks to highlight the occurrence of hypersensitivity to metals as an adverse effect of prosthesis implantation and its possible clinical outcomes. It also aims to explore new evidence bases that contribute to the diagnosis and reduce the incidence of this complication in future cases, such as the finding of a higher prevalence of nickel hypersensitivity in female patients.

Definitions, Acronyms, Abbreviations

ACD: allergic contact dermatitis

ICU: Intensive Care Unit

HRI: hypersensitivity reactions to implants

LMIT: leukocyte migration inhibition test

LTT: lymphocyte transformation test

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AUTHORS' CONTRIBUTIONS

Each author contributed individually and significantly to the development of this article: MBM Conceived the activities that led to the bibliographic review, interpreted the results of the study, wrote the article and participated in formatting of the article; LPR Planned the

activities that led to the study, survey of the medical records, and data collection; ATAM Planned the activities that led to the study, survey of the medical records, data collection, wrote the article; HCS Participated in the review process, formatting of the article and approved the final version; EBS Conceived the activities that led to the bibliographic review; MMM Conceived the activities that led to the bibliographic review; FFS Participated in the review process and approved the final version;JTAParticipated in the review process and approved the final version. All the authors have read and approved the final manuscript.

CONSENT

All authors declare that written informed consent was obtained from the patient for publication of this case report and accompanying images.

ETHICAL APPROVAL

This case report was conducted in accordance with the guidelines for research involving human subjects established by the Brazilian National Board of Health and the principles outlined in the Declaration of Helsinki. It was approved by the Ethics Committee of Evangelical University of Goiás(CAAE: 80274824.1.0000.5076, protocol: 7.097.797), and ethical agreements with the hospital institution were signed.Awaiver for informed consent was requested because the outcome involved a death unrelated to the therapeutic intervention or the subject of this study. To minimize inconvenience and protect the patient's identity, the waiver was requested and approved by the ethics department to which this work was submitted.

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with ethical standards.

DISCLAIMER (USE OF ARTIFICIAL INTELLINGENCE)

The authors acknowledge the use of GTP-4 for rewriting and editing this manuscript, specifically for refining the English grammar of the translated text, which was originally written in Brazilian Portuguese. The AI's role was strictly limited to improving grammatical accuracy and ensuring alignment with academic language standards, without adding any new information to the text. The details of AI usage are as follows:

1. The original manuscript, written in Brazilian Portuguese, was translated into English, and AI was employed to enhance the grammatical quality of the final version, adhering to academic English conventions.

2. Carefully designed prompts were used to guide the AI in making grammatical corrections and verifying the translation's consistency with academic norms.

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