Managing Contact Dermatitis Related to Amputee Care

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PRACTICE **POINTS**

- Incorporating a tailored patch testing panel that includes common prosthetic-related allergens (eg, rubber, metals, adhesives) can greatly improve the diagnosis and treatment of allergic vs irritant contact dermatitis in amputees.
- Effective management of irritant contact dermatitis in amputees involves reducing moisture and friction in the prosthetic socket with moisture-wicking liners, ensuring proper fit, and utilizing treatments such as topical antiperspirants and botulinum toxin injections.

Amputees who use prosthetic devices are particularly vulnerable to contact dermatitis due to factors such as moisture, friction, and prolonged exposure to prosthetic materials. Distinguishing between allergic contact dermatitis (ACD) and irritant contact dermatitis (ICD) can be difficult, as the symptoms often overlap; therefore, careful evaluation of patient history, clinical features, and diagnostic tests is required. Allergic contact dermatitis in amputees frequently is triggered by exposure to materials such as rubber, metal, and adhesives, whereas ICD often is caused by friction and moisture accumulation within the prosthetic socket. Effective management involves differentiating between ACD and ICD and subsequently using patch testing to identify specific allergens in cases of ACD. Treatment of ICD focuses on minimizing mechanical irritation, controlling moisture, and maintaining skin barrier function. Newer therapies, including botulinum toxin injections and laser hair removal, offer additional options for managing sweat-induced skin irritation in prosthetic users. A comprehensive understanding of the causes and presentation of both ACD and ICD is essential for improving prevention, diagnosis, and treatment strategies in this population.

Amputees who use prosthetic devices are particularly susceptible to contact dermatitis due to moisture, irritation, and prolonged contact with components of the device. Contact dermatitis accounts for approximately one-third of the dermatoses encountered by amputees who wear a prosthesis.[1] Diagnosing allergic contact dermatitis (ACD) and irritant contact dermatitis (ICD) is challenging due to errors of omission from the differential and the substantial clinical overlap with other eczematous dermatoses. Diagnosis relies on patient history, clinical examination, exposure assessment, diagnostic testing, and a high index of suspicion. Conventionally, ACD comprises approximately 20% of all contact dermatitis cases, whereas ICD accounts for 80%.[2] Symptoms vary between the 2 conditions, with pruritus more common in ACD and burning and soreness more common in ICD.[3] Onset of dermatitis relative to exposure is crucial, with ICD often manifesting more quickly and ACD requiring an initial sensitization phase.[4] Additionally, the complexity of ICD as a condition with variable features adds to the diagnostic difficulty, especially when allergens also have irritant effects.

Understanding these 2 primary types of contact dermatitis is crucial for effective management and prevention strategies in amputees who use prosthetics. In this article, we describe common causes of ACD and ICD related to amputee prosthetics and propose a tailored patch testing panel in order to better diagnose ACD in this patient population.

ALLERGIC CONTACT DERMATITIS

Allergic contact dermatitis occurs when the skin comes into contact with a substance to which the individual is sensitized. In amputees who use prosthetics, the socket and sock liner materials are frequent culprits for triggering allergic reactions. Components such as rubber, metals (eg, nickel), adhesives, and various plastic monomers can induce ACD in susceptible individuals. Additionally, chronic friction and sweat augment hapten penetration, increasing the risk of developing ACD.[5]

Contact allergens (typically small molecules under 500 Da) penetrate the skin, engage dendritic cells, activate T lymphocytes, and trigger the immune response and memory.[6] The skin contains a substantial population of memory T cells, with CD8+ T cells in the epidermis and CD4+ T cells in the dermis, expressing markers that facilitate skin reactivity. The balance between effector and regulatory T cells, which

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can produce suppressive cytokines such as IL-10, promotes clinical tolerance to allergens such as nickel.

Textile-driven ACD presents with a distinct clinical pattern, often manifesting as patchy generalized dermatitis that coincides with sites where garments fit most snugly. This presentation can mimic other forms of dermatitis, such as nummular or asteatotic dermatitis. The skin beneath undergarments such as underwear or prosthetic socks may be spared, as these act as shields from contact allergens. Notably, the face and hands typically are spared unless the patient has a cross-reaction to formaldehyde-based preservatives found in personal care products.[4]

Allergy to Components of the Prosthetic Socket and Sock Liner

A prosthesis consists of several key components, including a socket, sleeve, liner, and stump shrinker (eFigure 1). The prosthetic socket, custom-made to fit the residual limb, is the upper part of the prosthesis, while the lower part consists of prosthetic components such as joints and terminal devices ordered to meet individual needs. Prosthetic sleeves provide suspension by securely holding the prosthetic limb in place, while liners offer cushioning and protection to the residual limb, enhancing comfort and reducing friction. Stump shrinkers aid in reducing swelling and shaping the residual limb, facilitating a better fit for the prosthetic socket. Together, these components work in harmony to optimize stability, comfort, and functionality for the user, enabling them to navigate daily activities with greater ease and confidence. Common allergens found in components of the socket and sock liner include rubbers and other elastomers, metals, plastics, adhesives, and textiles.

Rubbers and Other Elastomers—Consumables, including liners, knee sleeves, and socks, are tailored to each client and utilize materials such as silicone and natural and synthetic rubbers for comfort and secure fit. Allergic reactions to natural rubber latex, more commonly used in earlier prosthetics, are associated with both type I and type IV hypersensitivity reactions.[4] Proteins inherent to natural rubber are overwhelmingly associated with an immediate urticarial eruption, whereas chemical additives used to produce latex are mostly linked to delayed hypersensitivity reactions, manifesting as allergic reactions ranging from mild itching to severe skin blistering.[4]

Vulcanization is the process of using heat and other accelerators to manufacture rubber. Common rubber accelerators include thiurams (the most common allergen associated with rubbers and other elastomers), carbamates/carba mix, 1,3-diphenylguanidine, and mercaptobenzothiazole.[4] Thiourea is an implicated cause of ACD to neoprene rubber.[7] These sensitizing chemicals are all included in the North American 80 Comprehensive Series; only thiuram mix, carba mix, and mercaptobenzothiazole are available in the T.R.U.E. TEST (SmartPractice). Sensitization often occurs due to repeated exposure, particularly in individuals who have undergone multiple prosthetic fittings. Many modern prospective liners utilize a medical-grade silicone as an elastomer for its high flexibility; silicone is considered biologically nonreactive and generally is considered a rare cause of ACD.[8]

Metals—Nickel, a ubiquitous allergen found in metal alloys used in prosthetic hardware, can cause localized itching, redness, and even blistering upon contact with the skin. Other metals, such as cobalt and chromium, also may trigger allergic reactions in susceptible individuals. Though many elastic fitting prosthetic socks contain silver fibers to reduce odors and friction-causing blisters, pure silver used in clothing or jewelry rarely causes dermatitis.[4]

Plastics and Adhesives—Leg prosthesis sockets typically are finished with the application of varnish, plastics, and/or resins—all potential allergens—to improve the appearance of the device and protect it from external agents.[9] Polyester plastics themselves can cause ICD, only rarely leading to ACD.[4] Incomplete curing during their manufacture may result in inadvertent exposure to epoxy resins or other phenol-formaldehyde resins such as 4-tert-butylcatechol and 4-tert-butylphenol formaldehyde, demonstrated causes of ACD in amputees.[10] Adhesives used in sock liners or tapes to secure prosthetic devices can contain ingredients such as acrylates (a well-known cause of nail allergens) and other formaldehyde resins.[4] Additionally, benzophenone commonly is added to paints and rubbers as a UV light absorber, reducing UV degradation and enhancing the material's durability under light exposure.[11]

Textiles—Cotton, a common component in prosthetic sock liners, is almost 100% cellulose and typically does not cause ACD; however, synthetic fibers such as polypropylene and elastane (spandex) can elicit allergic reactions.[4] Allergy to textiles often is driven by the chemicals used in the manufacturing process, particularly textile finishes, dyes, and formaldehyde resins, which are commonly used as fabric treatments. Disperse dyes are another common cause of allergic reactions. Para-phenylenediamine, a dye found in permanent hair dye and other darkly colored fabrics, is a potent sensitizer that may cross-react with other compounds that also contain similar amine groups, such as ester anesthetics, sunscreens containing para-aminobenzoic acid, other para dyes, and sulfonamides.[12] Sweat can exacerbate these reactions by causing allergens to leach out of textiles, increasing skin exposure. Additionally, prosthetics containing leather may trigger allergies to potassium dichromate and other chromium compounds used in the leather-tanning process.[12]

Allergy to Personal Care Products

Skin protectants and prosthetic cleansers are crucial in dermatologic care for amputees, working together to safeguard the skin and maintain prosthetic hygiene. Skin protectants form a barrier against irritation, friction, and moisture, protecting the residual limb from damage and enhancing comfort and mobility. Meanwhile, prosthetic cleansers remove sweat, oils, and bacteria from the prosthetic socket, reducing the risk of infections and odors and ensuring the longevity and optimal function of the prosthetic device. Together, they support skin health, comfort, and overall quality of life for amputees.

The socket should be cleaned with warm water prior to use, but more importantly, immediately after removing the prosthesis. If cleaning products are used at night, residual haptens may remain on the device, increasing the risk of sensitization. Common contact irritants found in personal care products utilized in amputee care include sulfates, surfactants, preservatives, and fragrances (eTable 1).[4] Additionally, common household cleaners and disinfectants can damage the prosthesis, leading to breakdown and the release of the monomers, precipitating ACD

Patch Testing to Identify Causative Allergens

Patch testing is a valuable tool for identifying specific allergens responsible for ACD in amputees. This procedure involves applying small amounts of suspected allergens to the patient's skin under occlusion and leaving the patches in place for 48 hours. After removal, the skin is assessed for reactions at 48 hours, with additional assessments conducted according to International Contact Dermatitis Research Group guidelines, typically at 72 and 96 hours, to identify delayed responses. This diagnostic approach helps pinpoint the substances to which the individual is allergic, enabling targeted avoidance strategies and treatment recommendations. Two widely used patch tests—the T.R.U.E. TEST, a preassembled patch test encompassing 35 allergens, and the North American 80 Comprehensive Series, which includes 80 allergens—demonstrate a sensitivity range between 70% and 80%.[13,14] eTable 2 shows a recommended custom contact dermatitis panel to assess the most common causes of ACD related to amputee care.

IRRITANT CONTACT DERMATITIS

Irritant contact dermatitis occurs when the skin's protective barrier is damaged by repeated exposure to a particular irritant. In amputees, perspiration, friction, and pressure from prosthetic devices can exacerbate irritant reactions, leading to skin maceration, breakdown, and increased transepidermal penetration. Sweat accumulation within the prosthetic socket creates a moist environment conducive to ICD. The combination of sweat and friction can strip the skin of its natural oils, leading to dryness, chafing, and maceration. Continuous exposure to moisture also can exacerbate existing dermatitis and compromise skin integrity.[4] Additionally, chronic irritation may increase transepidermal penetration of haptens, potentiating the development of ACD.[15]

Management of ICD in amputees involves a combination of treatments aimed at reducing friction, reducing sweating, and restoring barrier protection. Strategies to minimize mechanical trauma to the skin include ensuring proper socket fit, managing moisture, and protecting the skin. Using moisture-wicking sock liners and breathable prosthetic materials can help keep the skin dry. Topical antiperspirants containing aluminum chloride or similar compounds that help to block sweat glands often are the first line of treatment. Oral anticholinergics may be prescribed to reduce overall sweating, though they can have systemic side effects. Iontophoresis, a procedure where the affected area is exposed to a mild electrical current, can also be effective, especially for sweating of the hands and feet, though its application in amputees might be more limited.[14]

Recently, 2 treatments have emerged as options for managing excessive sweating (hyperhidrosis) in amputees: botulinum toxin injections and laser hair removal. By inhibiting the release of acetylcholine from sweat glands, botulinum toxin effectively reduces sweat production, thereby alleviating perspiration-induced skin irritation. Approximately 2 to 3 units of botulinum toxin at a dilution of 100 units in 1 mL of bacteriostatic saline 0.9% are injected transdermally at 1-cm intervals in a circumferential pattern on the skin covered by the prosthesis socket (typically a total of 300-500 units are utilized in the procedure) (eFigure 2).[16] Laser hair removal can assist amputees with hyperhidrosis by reducing hair in the residual limb area, which decreases sweat retention and the potential for skin irritation due to friction.

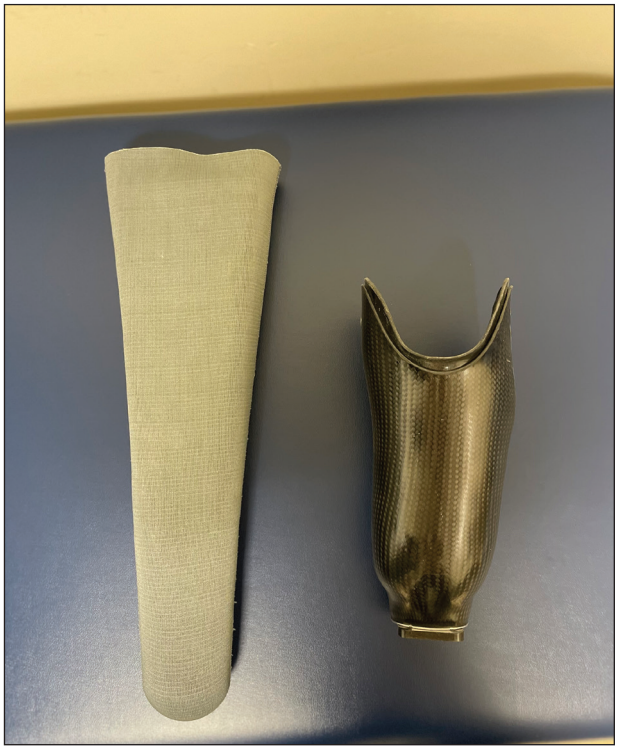
FINAL THOUGHTS

In amputee dermatologic care, individuals with limb loss are particularly prone to contact dermatitis due to moisture, friction, and prolonged contact with prosthetic components. Diagnosing ACD and ICD is challenging due to overlapping symptoms and the potential for simultaneous occurrence. Distinguishing between these conditions is crucial for effective management. Understanding their causes, particularly in relation to prosthetic use, is essential for developing targeted prevention and treatment strategies, including the use of tailored patch testing panels to better diagnose ACD in amputees.

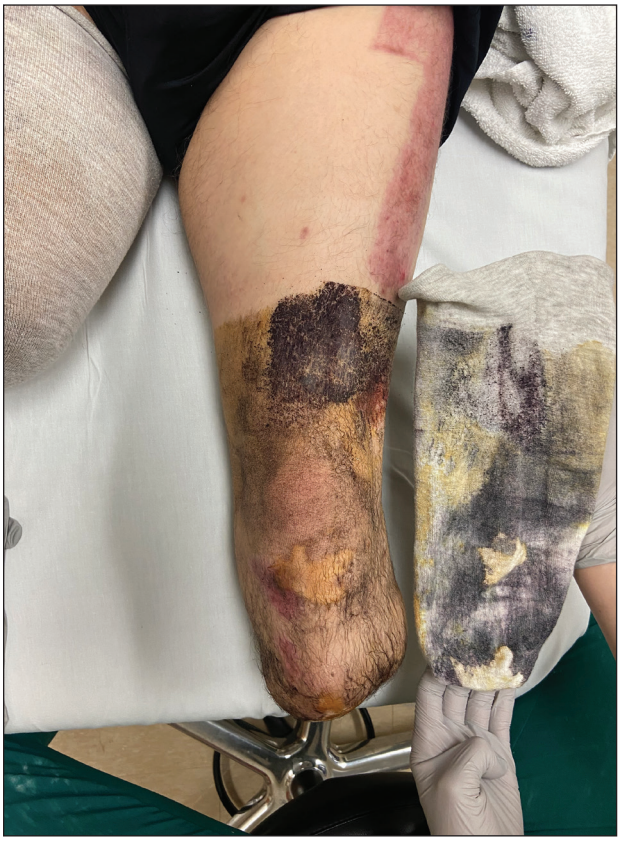
REFERENCES

1. Lyon CC, Kulkarni J, Zimersonc E, et al. Skin disorders in amputees. *J Am Acad Dermatol*. 2000;42:501-507.
2. Bains SN, Nash P, Fonacier L. Irritant contact dermatitis. *Clin Rev Allergy Immunol*. 2018;56:99-109.
3. Angelini G, Bonamonte D, Foti C, eds. *Clinical Contact Dermatitis: A Practical Approach*. Springer; 2021:57-92.
4. Fisher AA, Rietschel RL, Fowler JF. *Fisher's Contact Dermatitis*. BC Decker Inc; 2008.
5. Johansen JD, Frosch PJ, Lepoittevin JP. *Contact Dermatitis*. Springer; 2010:43-90.
6. Eisen HN, Orris L, Belman S. Elicitation of delayed allergic skin reactions with haptens: the dependence of elicitation on hapten combination with protein. *J Exp Med*. 1952;95:473-487.
7. Johnson R. Wrist dermatitis: contact allergy to neoprene in a keyboard wrist rest. *Am J Contact Dermat*. 1997;8:172-174.
8. Adams RM. *Occupational Skin Disease*. WB Saunders; 1999:501-551.
9. Requena L, Vázquez F, Requena C, et al. Epoxy dermatitis of an amputation stump. *Contact Dermatitis*. 1986;14:320.
10. Freeman S. Contact dermatitis of a limb stump caused by p-tertiary butyl catechol in the artificial limb. *Contact Dermatitis*. 1986;14:68-69.
11. Heurung AR, Raju SI, Warshaw EM. Benzophenones. *Dermatitis*. 2014;25:3-10.
12. Manneschi V, Palmerio B, Pauluzzi P, et al. Contact dermatitis from myoelectric prostheses. *Contact Dermatitis*. 1989;21:116-117.
13. Heinrich D, Altmeyer P, Brasch J. "New" techniques for more sensitive patch testing? *J Dtsch Dermatol Ges*. 2011;9:889-896.
14. James WD. Contact dermatitis update. Presented at: Walter Reed National Military Medical Center; April 18, 2024.
15. Smith HR, Basketter DA, McFadden JP. Irritant dermatitis, irritancy and its role in allergic contact dermatitis. *Clin Exp Dermatol*. 2002;27:138-146.
16. Lannan FM, Powell J, Kim GM, et al. Hyperhidrosis of the residual limb: a narrative review of the measurement and treatment of excess perspiration affecting individuals with amputation. *Prosthet Orthot Int*. 2021;45:477-486.

APPENDIX



eFIGURE 1. Transtibial prosthetic liner (left) alongside a definitive carbon fiber prosthetic socket (right). Credit: Walter Reed National Military Medical Center Amputee Clinic (Bethesda, Maryland).



eFIGURE 2. Starch iodine test used to treat areas of residual limb hyperhidrosis for botulinum toxin injections. Credit: Walter Reed National Military Medical Center Amputee Clinic (Bethesda, Maryland).

eTABLE 1. Potential Allergens in Popular Personal Care Products Used by Amputees

Product	Potential allergens in NAC-80
Prosthetic Cleanser (ALPS)	Cocamidopropylamine oxide, cocamidopropylamine betaine
Derma Clean (Ottobock)	Cocamidopropyl betaine, chlorhexidine digluconate, phenoxyethanol, parfum (fragrance)
Resilience Prosthetic Cleanser (Amputee Essentials)	Decyl glucoside, phenoxyethanol, sodium benzoate
Derma Prevent (Ottobock)	None
Resilience Liquid Powder (Amputee Essentials)	None
Resilience Chafe Barrier Cream (Amputee Essentials)	None

Abbreviation: NAC-80, North American 80 Comprehensive Series.

eTABLE 2. Proposed Amputee Dermatologic Care Specific Patch Testing Panel

Allergen	T.R.U.E. TEST (SmartPractice)	NAC-80
Rubbers/elastomers		
Thiuram mix	×	×
Carba mix	×	×
1,3-diphenylguanidine		×
Mercaptobenzothiazole	×	×
Metals		
Nickel	×	×
Cobalt	×	×
Plastics/adhesives		
Epoxy resin	×	×
4-tert-butylphenol formaldehyde	×	×
Acrylates	×	×
Textile allergens		
Para-phenylenediamine	×	×
Potassium dichromate	×	×
Surfactants		
Cocamidopropylamine betaine		×
Preservatives		
Chlorhexidine, digluconate		×
Paraben mix	×	×
Sodium benzoate		×
Fragrance		
Fragrance mix	×	×

Abbreviation: NAC-80, North American 80 Comprehensive Series.