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LOWER EXTREMITY REVIEW
October 25 / volume 17 / number 10

Not Just Varicose Veins: Congestive Lower Extremity Failure

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LOWER EXTREMITY REVIEW

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Richard Dubin
Publisher and Chief Executive Officer
rich@lermagazine.com | 518.221.4042

STAFF

Editor Emeritus
Janice T. Radak | janice@lermagazine.com

Editor
January Shoaf | january@lermagazine.com

Associate Editor
Laura Fonda Hochnadel | laura@lermagazine.com

Marketing Manager
Glenn Castle | glenn@lermagazine.com

Graphic Design/Production and Website Development
Anthony Palmeri | PopStart Web Dev
webmaster@lermagazine.com

Lower Extremity Review

Lower Extremity Review informs healthcare practitioners on current developments in the diagnosis, treatment, and prevention of lower extremity injuries. LER encourages a collaborative multidisciplinary clinical approach with an emphasis on functional outcomes and evidence-based medicine. LER is published monthly, except for a combined November/December issue and an additional special issue in December, by Lower Extremity Review, LLC.

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Showcasing evidence and expertise across multiple medical disciplines to build, preserve, and restore function of the lower extremity from pediatrics to geriatrics.

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- Movement is essential
- Injury prevention is possible
- Diabetic foot ulcers can be prevented
- Collaborative care leads to better outcomes

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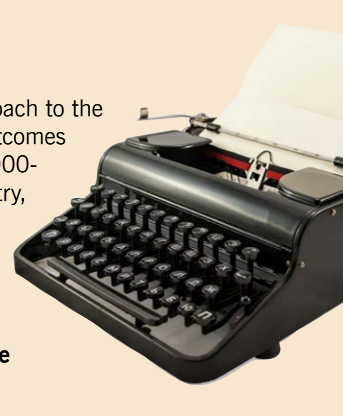

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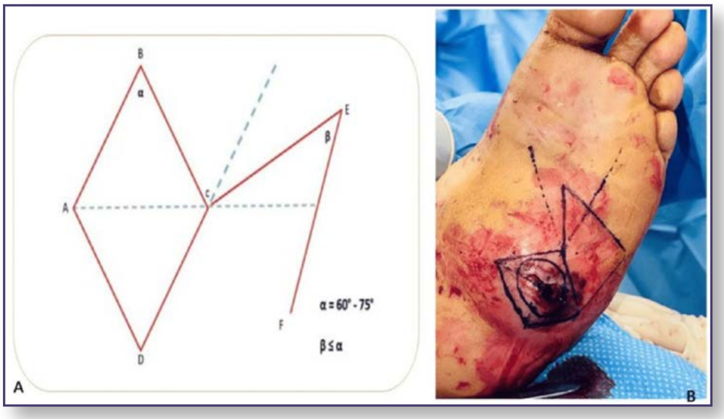
A NOVEL RECONSTRUCTIVE APPROACH FOR PLANTAR CHARCOT MIDFOOT ULCER



Dufourmentel rhomboid flap design and clinical execution. (A) Illustration showing rhomboid flap planning. Red solid lines indicate surgical incisions for wound excision and flap elevation. Blue dotted lines represent imaginary guides for flap orientation and angle planning. The flap pivot (D-F) was later depicted intraoperatively in the right using a solid marker line. (B) Intraoperative biogeometric skin markings replicating the schematic design, demonstrating translation of the flap plan to clinical application. The illustration is created by the authors of this study.

Chronic plantar ulcers in Charcot neuropathic osteoarthropathy (CNO) present a significant challenge in limb salvage due to biomechanical instability, poor tissue quality, and high mechanical stress at weight-bearing sites. Traditional surgical techniques, such as exostectomy and tendo-Achilles lengthening (TAL), effectively redistribute plantar pressure but often fail to provide durable soft tissue coverage. This study describes the first documented use of a Dufourmentel rhomboid flap for reconstructing a chronic plantar midfoot ulcer in a 59-year-old female with CNO and poorly controlled diabetes. The patient presented with a non-healing ulcer over a prominent osseous deformity, complicated by advanced neuropathy and a rocker-bottom foot. Surgical intervention included TAL, exostectomy, and meticulous wound debridement, followed by primary closure using a Dufourmentel flap to achieve tension-free, durable coverage. Postoperatively, the patient was managed with strict immobilization using a total contact cast and transitioned to a Charcot Restraint Orthotic Walker (CROW) boot. Despite partial non-compliance with weight-bearing restrictions, the wound healed completely by 6 months, with no recurrence. This case highlights the Dufourmentel flap as an innovative and effective reconstructive option for complex plantar ulcers in CNO, offering enhanced soft tissue resilience and long-term stability. The integration of TAL, exostectomy, and biomechanically optimized wound closure provides a comprehensive approach to limb salvage in high-risk diabetic patients. Further research is warranted to evaluate the flap's long-term outcomes and broader applicability in Charcot foot reconstruction.

Source: *Elhaddad M, Carrillo-Kashani A, Tavakalyan K, Massaband BD. Dufourmentel rhomboid flap for plantar charcot midfoot ulcer: a novel reconstructive approach. Cureus. 2025 30;17(3):e81484. doi: 10.7759/cureus.81484.*

DESIGN, DEVELOPMENT, & VALIDATION OF AAFO FOR TWIN LOWER-LIMB EXOSKELETON

Current exoskeletons with active ankle joints provide active dorsiflexion during the swing phase, they do not quantify how this ankle motion enhances the device's ability to effectively increase toe clearance and prevent stumbling during level ground walking. This study's primary objective was to develop an Active Ankle-Foot Orthosis (AAFO) specifically designed for integration into lower-limb exoskeletons. An analysis of human ankle motion is conducted to inform the development process, guiding the creation of an AAFO that aligns with specifics extrapolated by real data. The AAFO incorporates an electric motor with a non-back drivable transmission system, engineered to reduce distal mass, minimize power consumption, and enable high-precision position control. Capable of generating up to 50 N-m of peak torque, the AAFO is designed to provide support throughout the walking cycle, targeting pathological conditions such as foot drop and toe drag. Performance was first validated through benchtop experiments under unloaded conditions. The AAFO was then integrated into the TWIN lower-limb exoskeleton, employing an optimal trajectory planning method to generate compatible reference trajectories.

These trajectories are designed to help the user maintain ground contact during the support phase while ensuring safe toe clearance and minimizing jerk during the swing phase. Finally, the AAFO's performance was assessed in real-world application conditions, with 4 healthy participants walking with the TWIN lower limb exoskeleton. The results suggest that the proposed AAFO efficiently reduces toe clearance, ensures stable control, and maintains low power consumption, highlighting its suitability for clinical applications.

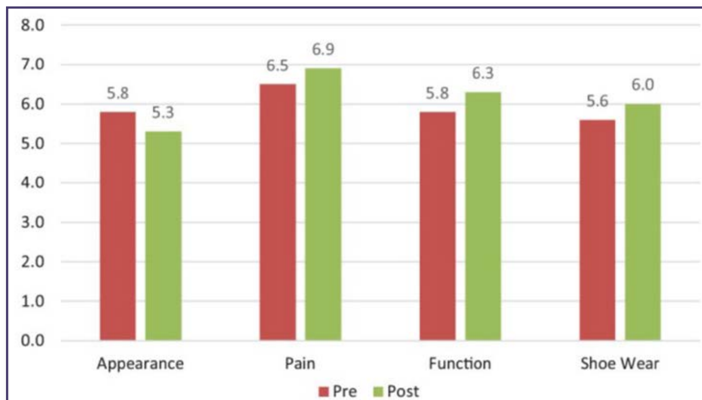
Source: *Giannattasio R, Boccardo N, Vaccaro R, et al. Design, development, and validation of a non-backdrivable active ankle-foot orthosis for the twin lower-limb exoskeleton. Front Robot AI. 2025 18;12:1647989. doi: 10.3389/frobt.2025.1647989. Use is per CC BY.*

ANATOMY OF PLANTARIS TENDON AND MANAGEMENT OF MIDPORTION ACHILLES TENDINOPATH

Midportion Achilles tendinopathy (Mid-AT) is a complex condition that may be exacerbated by anatomical variations of the plantaris tendon. Recent anatomical studies, particularly the classification proposed by Olewnik et al., have enhanced the understanding of plantaris-Achilles interactions and their clinical implications. This review aims to assess the anatomical types of the plantaris tendon, their imaging correlates, and the impact of the Olewnik classification on diagnosis, treatment planning, and surgical outcomes in patients with Mid-AT. The researchers present an evidence-based analysis of the 6 anatomical types of the plantaris tendon and their relevance to Achilles tendinopathy, with emphasis on MRI and ultrasound (USG) evaluation. A diagnostic and therapeutic algorithm is proposed, and clinical outcomes of both conservative and operative management are compared across tendon types. Types I and V were most strongly associated with symptomatic conflict and showed the highest benefit from surgical resection. Endoscopic approaches were effective in Types II and III, while Type IV typically responded to conservative treatment. Type VI, often misdiagnosed as tarsal tunnel syndrome, required combined neurolysis. The classification significantly improves surgical decision-making, reduces overtreatment, and enhances diagnostic precision. The Olewnik classification provides a reproducible, clinically relevant framework for individualized management of Mid-AT. Its integration into imaging protocols and treatment algorithms may improve therapeutic outcomes and guide future research in orthopedic tendon pathology.

Source: *Olewnik L, Landfald IC, Gonera B, et al. Does the anatomical type of the plantaris tendon influence the management of midportion achilles tendinopathy? J Clin Med. 2025 4;14(15):5478. doi: 10.3390/jcm14155478. Use per CC BY.*

WHY I WANT BUNION SURGERY—THE PATIENT'S PERSPECTIVE



Hallux valgus is the most common pathology afflicting the hallux. Surgery is generally offered to symptomatic patients who fail conservative treatment. The aim of this study is to evaluate patient-reported reasons for undergoing hallux valgus corrective surgery in a preoperative and postoperative cohort. Researchers performed a prospective and retrospective cross-sectional study. The study included all patients aged >18 years who were planning to or have had hallux valgus surgery during the study period. An information sheet including 14 possible reasons for having hallux valgus surgery and a questionnaire to rank each reason (1-10) was sent to all patients. Patients were divided into a preoperative group and a postoperative group to eliminate bias. In the study researchers had 101 patients, 5 males and 96 females, at an average age of 50.6 years.

The preoperative cohort included 51 patients and the postoperative cohort 50 patients. The 3 most important reasons for having surgery, in both cohorts, were the ability to move pain free, eliminate pain over bunion, and to be able to walk long distances and over uneven terrain without pain. The 3 least important factors were to reduce the need for an orthotic, narrower foot, and to wear high heels. Indications were divided into 1 of 4 categories. Pain was the highest-rated category in both

Continued on page 12

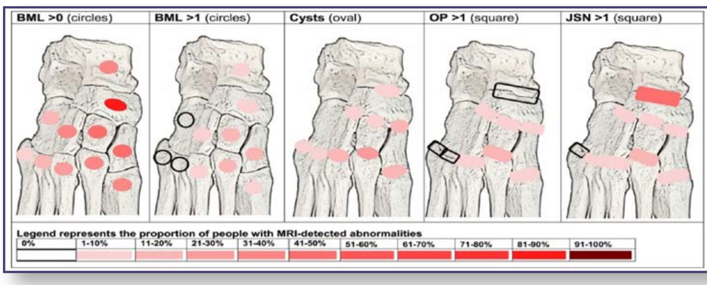
Continued from page 11

pre and postoperative groups, followed by function. In the preoperative group, appearance was the next most important group and shoe wear the least. In comparison, in the postoperative group, shoe wear was more important than appearance.

Pain and function are the most important reasons patients have for surgery in both the preoperative and postoperative patient cohorts. Patients were more likely to list cosmesis as a reason to undergo surgery in the preoperative than the postoperative group.

***Source:** de Buys M, Saragas NP, Ferrao PNF. Why i want bunion surgery-the patient's preoperative and postoperative perspective. Foot Ankle Int. 2025;46(4):410-414. doi: 10.1177/10711007251321475.*

STUDY COMPARES CLINICAL AND MRI FINDINGS FOR MIDFOOT PAIN



Midfoot pain is common but poorly understood, with radiographs often indicating no anomalies. This study aimed to describe bone, joint and soft tissue changes and to explore associations between MRI-detected abnormalities and clinical symptoms (pain and disability) in a group of adults with midfoot pain, but who were radiographically negative for osteoarthritis.

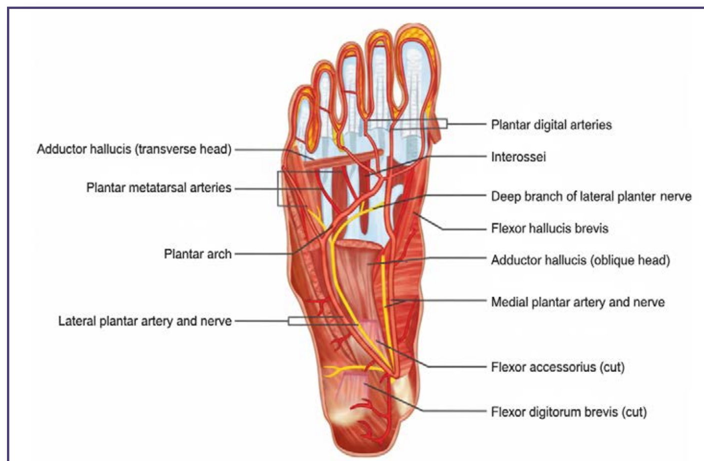
Community-based participants with midfoot pain underwent an MRI scan of 1 foot and scored semi-quantitatively using the Foot OsteoArthritis MRI Score (FOAMRIS). Linear regression was used to explore the association between participant-reported measures and MRI abnormalities, adjusted for age, sex and BMI.

Sixty-one participants (70% female, mean age 48.5 years, median BMI 28.6 kg/m2) were included. Median visual analog scales (VAS) pain was 31/100 mm (IQR 21–47) and median disability was 30/48 (IQR 26–36). There was a moderate association between midfoot pain severity and the number of joints exhibiting joint space narrowing; adjusted results suggested 31% (95% confidence interval 3%–68%) worse VAS pain with each additional affected joint. Greater numbers of joints with cysts were associated with worse VAS pain [14% (0%–31%)] and disability [1.1 units (0–2.2)]. Effusion/synovitis was associated with MMFPDI pain. No other MRI abnormalities were associated with sex, body mass and foot pain/disability measures. MRI abnormalities were common, particularly in the talo-navicular joint, first and second cuneo-metatarsal joints. Those with dorsal foot pain had more multi-joint involvement, bone marrow lesions, joint space narrowing and cysts and for those with pain on midfoot movement, bone marrow lesions and cysts were reported.

In people with midfoot pain, MRI-detected features of osteoarthritis and soft-tissue abnormalities were found, clustered in the medial and intermediate cuneiform joints. These features were more common with age but not associated with pain or disability measures. Younger people with dorsal midfoot pain exhibited early signs of bone and joint features of osteoarthritis and we recommend further imaging studies to determine the clinical and diagnostic significance.

***Source:** Halstead J, Martín-Hervás C, Hensor EMA, et al. Association between clinical and MRI-detected imaging findings for people with midfoot pain, a cross-sectional study. J Foot Ankle Res. 2025;18(1):e70019. doi: 10.1002/jfa2.70019. Use per CC BY.*

DIAGNOSTIC ADVANCEMENTS IN EARLY DETECTION OF DIABETIC NEUROPATHY



Diabetic neuropathy (DN) is a widespread complication of diabetes, affecting nearly 50% of individuals with the condition. It commonly begins with the gradual loss of sensation in the lower extremities, particularly in the feet. If left undetected and untreated, this loss of sensation can lead to serious consequences, such as foot ulcers and eventual amputations. Early detection is critical to preventing irreversible nerve damage and minimizing the risk of such severe outcomes. However, current diagnostic methods often fail to identify neuropathy at an early stage, when intervention could still halt or reverse nerve degeneration.

The medial and lateral plantar nerves, responsible for sensory innervation in the foot, are among the first to show signs of damage in DN. Monitoring these nerves offers a potential avenue for early diagnosis. Techniques such as nerve conduction studies (NCS) and quantitative sensory testing (QST) allow for the assessment of nerve function in the distal extremities, where neuropathy typically begins. Early identification of nerve dysfunction through these methods can lead to timely intervention, significantly improving patient outcomes and reducing the risk of severe complications. Addressing the early signs of neuropathy is essential in managing the growing prevalence of diabetes-related complications.

Source: *Ahmed GU, Ahmed A, Raza AA, et al. Diagnostic advancements in early detection of diabetic neuropathy: comparative analysis of medial and lateral plantar nerve degeneration. Ann Med Surg (Lond). 2025 30;87(7):4325-4335. doi: 10.1097/MS9.0000000000003441.*

FIRST MTP JOINT-PRESERVING SURGERY FOR FOREFOOT DEFORMITY IN PATIENTS WITH RA

Arthrodesis of the first metatarsophalangeal (MTP) joint has been the gold standard for surgical treatment, particularly in cases of advanced joint destruction. This procedure is favored for its effectiveness in alleviating pain and improving function, despite sacrificing joint mobility. This study compares the clinical outcomes of first MTP joint fusion vs joint-preserving surgery in rheumatoid arthritis (RA) patients with severe forefoot deformities.

This single-center retrospective study at Kyushu University Hospital reviewed RA patients who underwent either first MTP joint arthrodesis or joint-preserving surgery for hallux valgus (HV) deformity between January 2008 and December 2022. A total of 103 feet (73 cases) were analyzed, with 75 feet (58 cases) showing radiographic bone destruction of Larsen grade 3 or higher. Surgical procedures included joint-preserving biplane osteotomy or arthrodesis with crossed screws.

This study analyzed 74 feet undergoing either arthrodesis (27 feet) or joint-preserving surgery (47 feet) for HV. Patients in the 2 groups showed similar demographic and clinical characteristics except with respect to length of follow-up, which was greater in the arthrodesis group (5.1 ± 2.6 years vs 2.4 ± 2.0 years, P < .01) than the joint-preserving group. In the arthrodesis group, all patients underwent resection arthroplasty on the second to fifth toes. The joint-preserving group included first MTP joint surgery alone (n = 5) and first MTP joint and lesser MTP joint surgeries (resection arthroplasty, n = 29; joint-preserving surgery, n = 13). Functional scores significantly improved in both groups, with first metatarsophalangeal joint-preserving surgery yielding better postoperative outcomes. In cases of deformity recurrence, the recurrent cases exhibited greater immediate postsurgical HVA, but other foot function outcomes remained similar at the end of follow-up.

Joint-preserving surgery for advanced rheumatoid forefoot deformity showed better functional improvement than arthrodesis using the propensity score matching and comparable clinical outcomes, highlighting it as a potential treatment option for severe joint destruction.

Source: *Sakai S, Fujiwara T, Yamaguchi R, et al. First metatarsophalangeal joint-preserving surgery is effective for forefoot deformity with moderate to severe joint destruction in rheumatoid arthritis. Foot Ankle Orthop. 2025 25;10(1):24730114251322790. doi: 10.1177/24730114251322790.*

DIABETIC FOOT INFECTION IN RELATION TO BACTERAEMIA AND ENDOCARDITIS

Diabetic foot infections (DFIs) are one of the most important components causes for foot related hospitalization, surgery and lower extremity amputation. In addition to foot specific complications, DFIs are also associated with an increased risk of systemic complications such as acute kidney injury, central line infections, bacteraemia and endocarditis. This study aimed to identify the incidence of blood stream infections (BSIs) and endocarditis in patients with DFIs, risk factors and clinical outcomes. A post hoc analysis of 280 patients using pooled patient level data from 3 RTCs. Blood cultures were drawn at time of admission for DFI. Deep intraoperative cultures were obtained from infected foot wounds. Data from the 12-month follow-up were used to determine clinical outcomes. 77.1% (N = 216) had blood cultures of which 15.7% (n = 34) had BSI. One patient (3.3%) had endocarditis. Risk factors for BSI included Charcot Neuroarthropathy history (20.6% vs. 7.1%, $P = 0.03$), low systolic blood pressure (128.3 ± 21.0 vs. 140.8 ± 22.2 $P = 0.003$), low diastolic blood pressure (71.6 ± 9.4 vs. 79.3 ± 11.5 $P < 0.001$), leucocytosis >12 000 (55.9% vs. 29.1%, $P = 0.002$) and elevated C-reactive protein (CRP) (26.8 ± 31.2 vs. 12.0 ± 19.6, $P < 0.001$). During the index hospitalization, BSI patients had longer median hospitalizations (14.0, 11.3–18.0 vs. 12.0, 9.0–16.0, $P = 0.04$). At 12-months, BSI patients were more likely to be admitted to the hospital (all cause hospital admissions 35.3% vs. 18.6%, $P = 0.03$). There was no difference in re-infection (20.6% vs. 32.9%, $P = 0.21$), foot-specific hospitalizations (17.6% vs. 22.5%, $P = 0.65$), wounds healing (64.7% vs.

Continued on page 14

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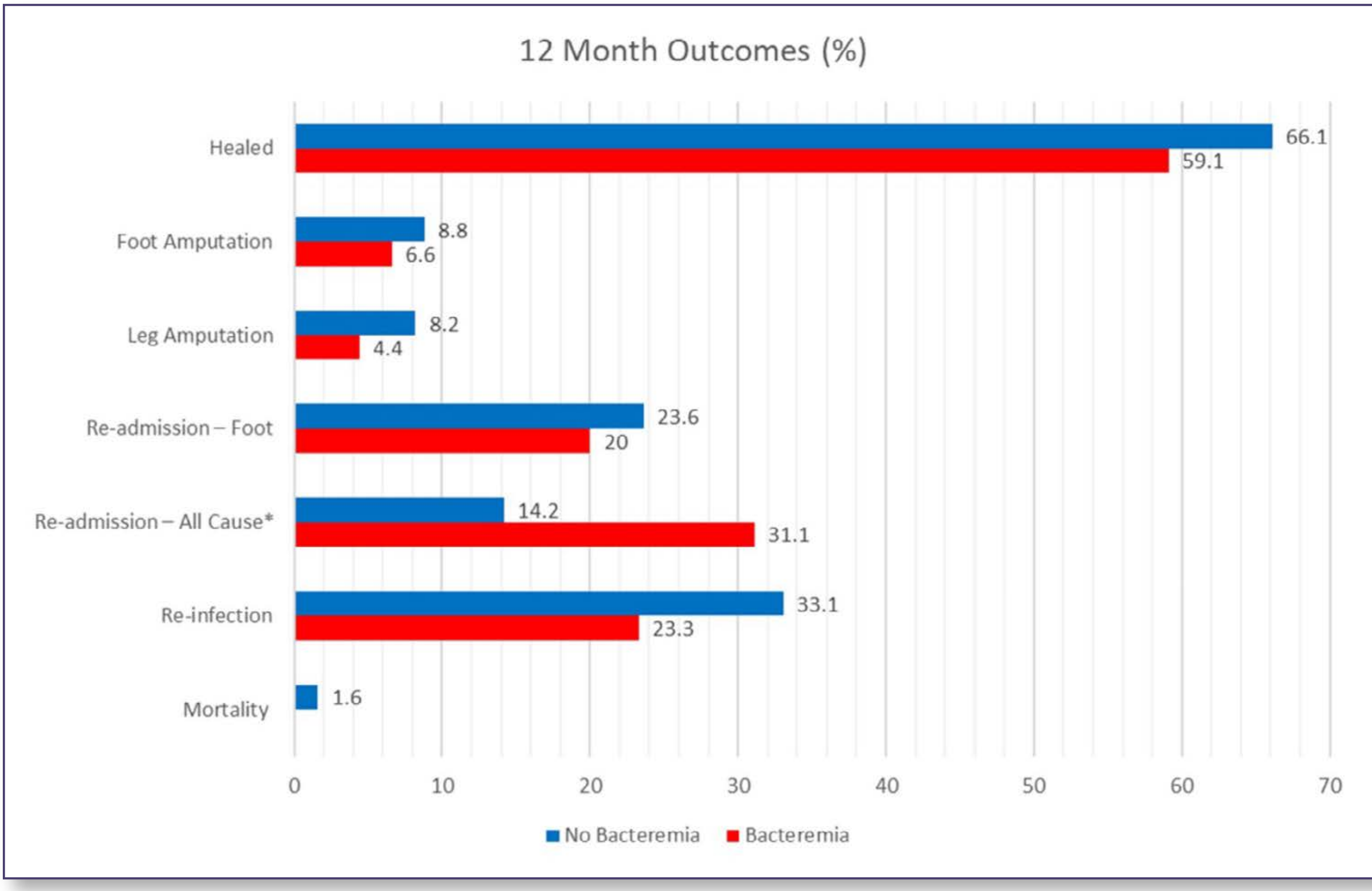

Outcome comparison in patients with bacteraemia or without bacteraemia. This bar chart compares the clinical outcomes in patients with bacteraemia to those without bacteraemia during the 12-month follow-up period after the index surgery. There was a significant difference in all cause readmissions. * is statistically significant.

67.5%, $P = 0.88$), time to heal (221.0, 74.0–365 vs. 109.5, 46.8–365, $P = 0.16$) or antibiotic duration (46.0, 39.3–76.5 vs. 45.0, 22.3–67.0, $P = 0.09$). The most common BSI pathogens were Staphylococcus aureus (79.4%) and Streptococcus spp. (50.0%) species. BSI is common in DFIs. Patients have longer hospitalizations and were more likely to be hospitalized after their initial discharge.

Source: *Reyes MC, Tarricone AN, Sideman MJ, Siah MC, Najafi B, Peters EJG, Lavery LA. The infected diabetic foot: bacteraemia and endocarditis complicating moderate and severe foot infections. Int Wound J. 2025;22(5):e70102. doi: 10.1111/iwj.70102.*

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Congestive Lower Extremity Failure (CLEF)

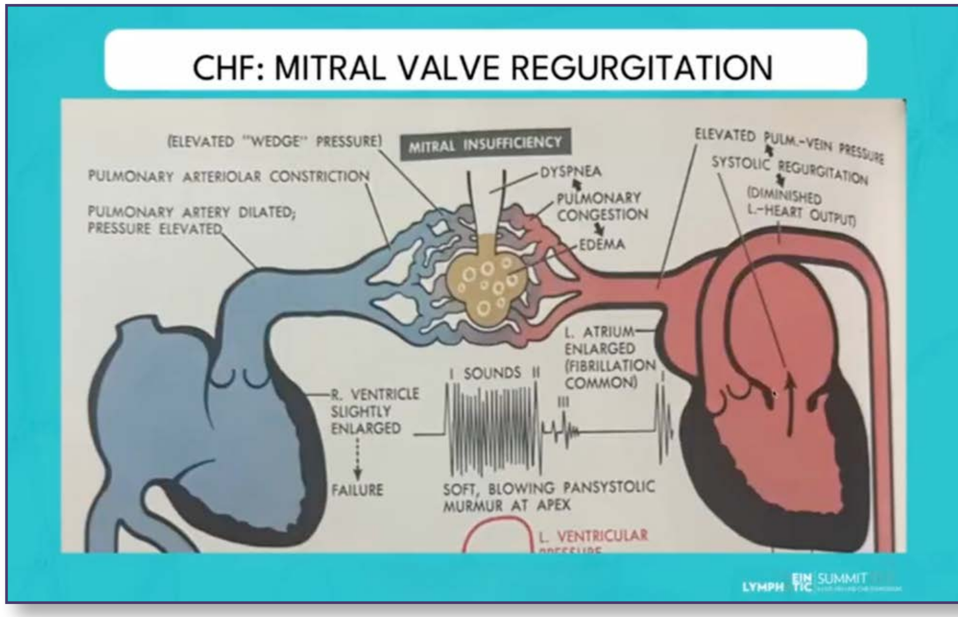
BY JOHN CHUBACK, MD

Healthcare professionals are continually striving to improve patient outcomes through enhanced understanding and precise diagnosis. Yet, a significant pathological continuum, chronic venous insufficiency (CVI) and chronic venous disease (CVD), remains grossly underrecognized and misunderstood by many across the healthcare spectrum. This gap in knowledge often leads to delayed or incorrect diagnoses, suboptimal patient care, and unnecessary suffering for millions worldwide.

Congestive lower extremity failure (CLEF) is a novel concept, recently published in the *Journal of Vascular Surgery: Venous and Lymphatic Disorders,* that aims to demystify the complex pathophysiology of CVI by drawing a direct and insightful analogy to a condition profoundly understood by clinicians: Congestive heart failure (CHF). The motivation behind CLEF is simple yet profound: to translate the intricate cellular, molecular, and genetic complexities of CVI into a basic, understandable framework for all healthcare colleagues, from physicians and nurses to physician assistants and wound care specialists.

The Urgent Need for a New Educational Model

For too long, CVD, particularly its earlier manifestations like varicose veins, has been mistakenly perceived as merely a cosmetic concern rather than a serious medical condition. This misperception, unfortunately, is still held by so many healthcare professionals, hindering the provision of optimal patient care and clinical outcomes. As a cardiac surgeon transitioning into the field of varicose vein treatment, I realized that venous issues were much more than varicose veins–they were part of a larger, complex clinical spectrum.



It was this background in open heart surgery that provided the crucial inspiration for the CLEF model and an obvious correlation between CHF as an educational model and CVI. By aligning the progression of CVI with the well-understood stages of CHF, CLEF offers a familiar and intuitive framework for clinicians to grasp the gravity and progressive nature of venous disease.

CLEF Explained: A Parallel Path to Organ Failure

The genius of the CLEF concept lies in its parallel progression with CHF, highlighting shared underlying principles of congestion and progressive organ dysfunction. Let's break down this powerful analogy:

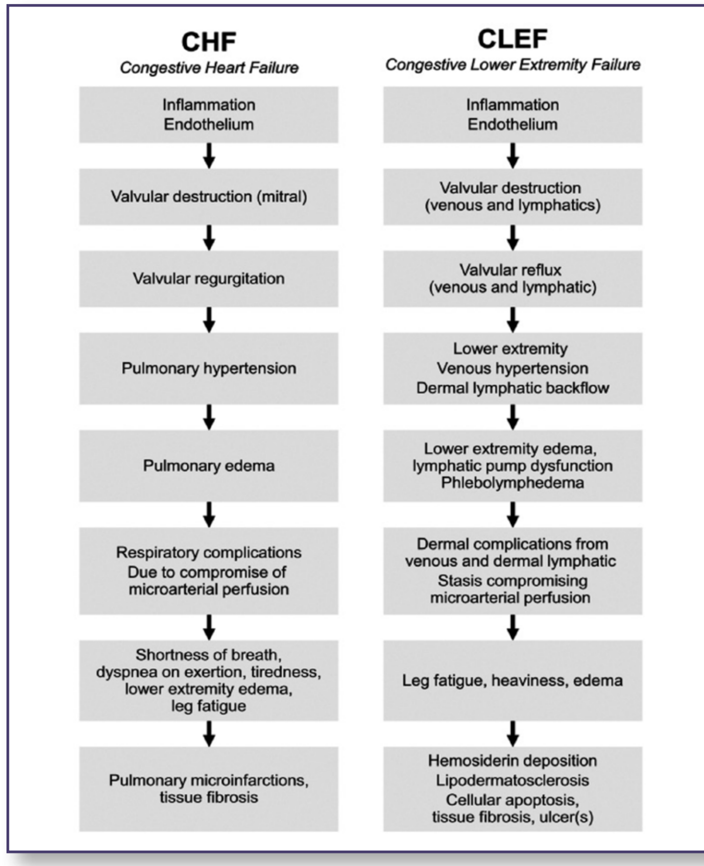
- **Initial Pathological Event:** Both CHF and CLEF begin with inflammation at the endothelial level. Under the common model for CHF, this leads to valvular destruction, particularly of the mitral valve. Similarly, in CLEF, this inflammation leads to valvular destruction of the venous valves.
- **Early Effect and Backflow:** This valvular damage leads to valvular regurgitation in CHF (ie, mitral valve regurgitation). In CLEF, this manifests as valvular reflux, such as saphenofemoral reflux, allowing blood to flow backward.
- **Pressure Build-up:** The consequence of this backflow is a rise in pressure. In CHF, we see pulmonary hypertension in

This article is a summary of Dr. Chuback's presentation, "Congestive Lower Extremity Failure (CLEF): A Novel Educational Model for Improved Understanding of Chronic Venous Insufficiency and Associated Advanced Stage Consequences," from the 2024 Vein Lymphatic Summit held July 19–20, 2024. To view the full presentation with questions and answers and see the agenda for the 2-day program, visit https://vls24.lerexpo.com/ . Continuing education credits are available for this and many of the lerEXPO programs.

the pulmonary veins. Analogously, CLEF involves lower extremity venous hypertension and dermal lymphatic backflow, as fluid struggles to return to the heart.

- **Fluid Accumulation and Organ Overload:** This elevated pressure leads to fluid accumulation. In CHF, this is pulmonary edema, a volume overload in the lung parenchyma. For CLEF, it results in lower extremity edema and phlebolymphedema, indicating a dysfunction and overwhelming of the lymphatic pump mechanism.
- **Clinical Manifestations:** The clinical symptoms of CHF include respiratory complications, dyspnea on exertion, fatigue, and lower extremity edema. In CLEF, patients experience leg fatigue, heaviness, persistent edema, and dermal complications like stasis, often accompanied by compromise of microarterial perfusion.
- **End-Stage Complications:** The progression culminates in severe organ damage. In CHF, this can lead to pulmonary microinfarctions, tissue fibrosis, and ultimately pulmonary failure. In the context of CLEF, the end stage is characterized by hemosiderin deposition, lipodermatosclerosis, cellular apoptosis, significant tissue fibrosis, and critically, venous leg ulceration.

Illustrating this analogy is a classic medical drawing of CHF by Dr. Netter and a compelling image depicting a normal leg versus one suffering from CLEF.



Another image shows a patient with end-stage CLEF (C6 disease), marked by severe venous hypertension, hemosiderosis, lipodermatosclerosis, venous dermatitis, active ulceration, and superficial thrombosis.

These visual aids powerfully convey the severity and progression of CLEF as a very real disease and pathology.

The Transformative Benefits of Increased Awareness

The adoption of the CLEF model promises significant benefits for patient care by fostering improved rates of recognition and accurate diagnosis among non-vein specialists and clinicians. This includes a wide array of healthcare professionals such as arterial surgeons, cardiologists, general surgeons, podiatrists, dermatologists, internists, and family practitioners.

Greater awareness directly translates to increased implementation of appropriate therapy and the full implementation of societal guidelines. This comprehensive approach includes:

- **Compression therapy:** A cornerstone of CVI management.
- **Interventional procedures:** Addressing both superficial and deep venous systems.
- **Manual lymphatic drainage and lymphedema pumps:** Crucial for managing the lymphatic component of phlebolymphedema.
- **Oral venoactive agents:** Such as micronized purified flavonoid fraction.

Ultimately, the widespread education afforded by the CLEF model is projected to prevent progression to more advanced stages of CVD and prevent end-stage CLEF for millions globally. This will significantly assist in improving the quality of life and reducing suffering for those already symptomatic and diagnosed with advanced stages of CVI.

CLEF is more than just a new term; it is a vital educational tool designed to underscore that CVI is a serious pathological continuum, not just a cosmetic problem. By embracing this paradigm, clinicians can enhance their diagnostic acumen, implement timely and effective treatments, and fundamentally transform the lives of countless patients suffering from this often-overlooked condition.

Dr. John Chuback is the founder of Chuback Vein Center, and is board-certified in Cardiovascular and Thoracic Surgery, and is a Diplomate of the American Board of Venous and Lymphatic Medicine. Dr. Chuback is also the founder of VItasupportMD, a brand of doctor-formulated dietary supplements that support healthy veins, lymphatics, and circulation.

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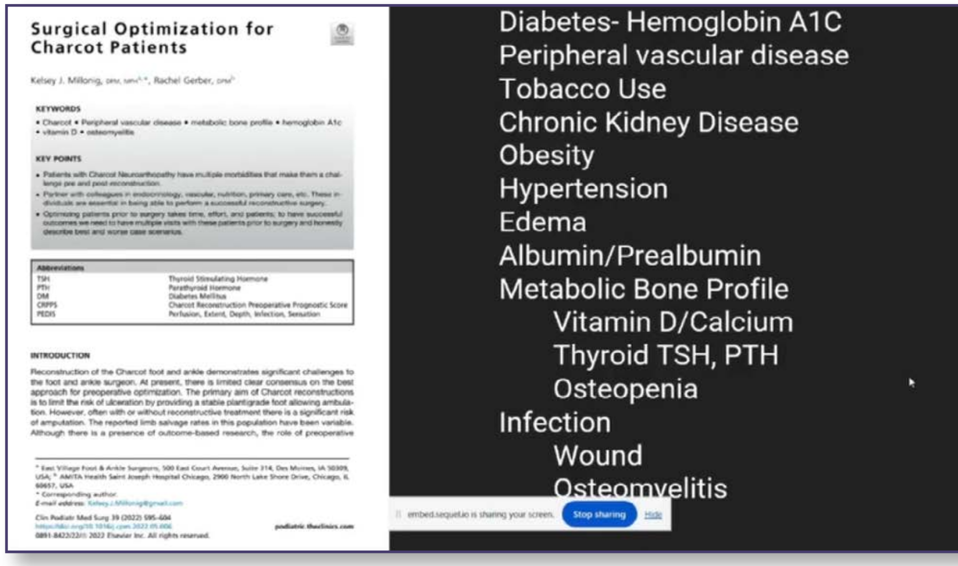
Management of Charcot Soft Tissue Complications

By Kelsey Millonig, DPM, MPH, FACFAS, DABPM, DABFAS

Charcot neuroarthropathy is a complex condition that often leads to considerable challenges due to its complex nature. One primary concern is the management of soft tissue complications, including chronic wounds and surgical dehiscence, which are prevalent among Charcot patients. These complications can significantly impact limb functionality and the patient's quality of life. Therefore, understanding and addressing these issues is crucial for optimizing patient outcomes. By employing preventative measures, conducting thorough assessments, and strategically using reconstructive techniques, one can effectively manage Charcot soft tissue complications to promote better patient outcomes.



Prevention Strategies

Patient Optimization Before Surgery: Preventing soft tissue complications in Charcot patients begins with meticulous pre-operative preparation. Comprehensive patient optimization is essential to enhance the outcomes of reconstructive surgery. This involves thorough lab work; reviewing A1C levels, albumin, and pre-albumin; and conducting a full metabolic bone profile, including assessments of vitamin D, calcium, thyroid levels, and parathyroid hormone. An extensive vascular workup is also crucial, encompassing non-invasive studies and arterial duplexes, with consultations from vascular specialists if required. Additional steps include ensuring smoking cessation, managing edema effectively, and handling comorbid conditions such as chronic kidney disease. Identifying and addressing any existing infections pre-operatively, through wound assessment or osteomyelitis diagnosis, is critical. Prophylactic use of intranasal calcitonin is also advised, based on its minimal risk and potential benefit.

Importance of Vascular and Infection Assessments: Ensuring proper blood flow is pivotal in the pre-operative phase. Vascular assessments must go beyond basic non-invasive tests to include comprehensive arterial duplex imaging; also consider pre-surgical vascular consultations to address any concerns about limb perfusion. Accurately diagnosing and managing any infections before surgery is vital; thorough assessments involve clinical evaluations, lab work, and imaging where CT scans are preferred over MRIs due to the latter's potential to misdiagnose Charcot as osteomyelitis. The objective is to mitigate infection risk, manage edema, and optimize circulatory health to enhance surgical outcomes.

Assessing Soft Tissue Complications

Identifying Infection: Clinical and Laboratory Methods: When a Charcot patient presents with soft tissue complications, the primary investigation should focus on determining if there is an infection. This includes assessing the clinical appearance of the wound, conducting laboratory tests, and considering imaging options. White blood cell labeled bone scans or MRIs are valuable tools for identifying osteomyelitis, however neither is completely definitive. Gathering cultures and biopsies from the operating room provides direct insights, and taking an antibiotic holiday of at least 2 weeks before a definitive bone biopsy is advised. Cultures should be comprehensive, covering aerobic, anaerobic, acid-fast bacteria, and fungal types.

This article is a summary of Dr. Millonig's presentation titled, "Management of Charcot Soft Tissue Complications," from the APMA Surgical Complications Virtual Seminar, January 18, 2025. To view the 20-minute slide presentation with questions and answers, visit https://apmasurgical.lerexpo.com/. Continuing education credits are available for many lerEXPO programs.

Continued on page 22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Continued from page 20

Role of Imaging in Diagnosis: Imaging plays a critical role in diagnosing soft tissue complications. Despite being a common choice for detailed imaging, an MRI may not reliably differentiate between Charcot changes and infections such as osteomyelitis, leading to a potential misdiagnosis. For evaluation of the deformity and bone quality, CT scans are preferred.

Evaluating Biomechanical Considerations: Addressing underlying biomechanical issues is essential for long-term success in treating soft tissue complications. Often, recurring wounds are not just soft tissue problems but signify biomechanical instability or deformities that need correction. For example, lack of plantar flexion or previous surgical failures may necessitate procedures like ankle fusion to rectify the problem and achieve sustainable healing. Surgical interventions should thus complement biomechanics to prevent wound recurrence and support overall structural stability.

The Reconstructive Elevator Concept

When managing Charcot soft tissue complications, the "reconstructive elevator" framework provides a strategic and tiered approach to selecting surgical techniques. This concept allows healthcare professionals to begin with simpler methods and progress to more advanced techniques as needed, optimizing the treatment process for each unique case.

Initial Options: Dermal Grafts and Local Flaps: The initial steps in the reconstructive elevator focus on dermal grafts and local flaps. Dermal grafts provide a scaffold for vascular growth, thereby promoting healing. Specifically, placental grafts can be placed over exposed bone to initiate tissue regeneration, provided there is no infection. Simple techniques like these can sometimes accomplish the task without resorting to more complex procedures.

Local flaps, including advancement, transpositional, and rotational flaps, are valuable for their ability to close defects by mobilizing adjacent tissue. These techniques require a solid understanding of surgical principles and are considered workhorses due to their versatility in closing various defects.

Surgical interventions should thus complement biomechanics to prevent wound recurrence and support overall structural stability.

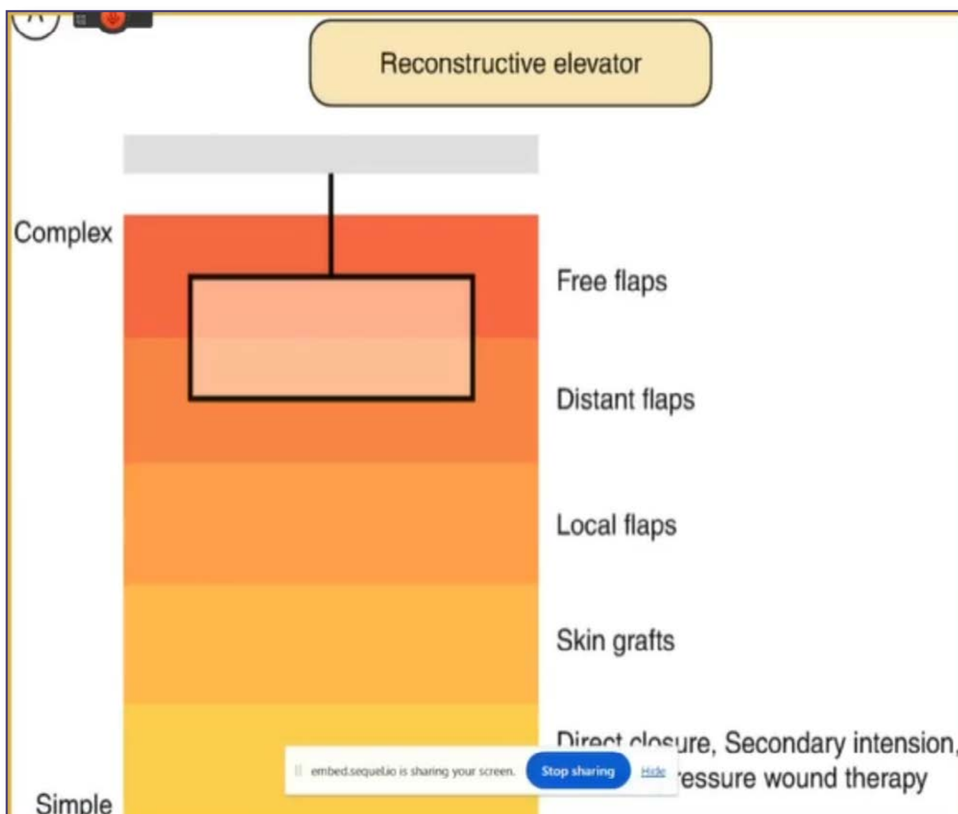
Advancing to Fascia Cutaneous and Adipofascial Flaps: For small to medium defects, fascia cutaneous and adipofascial flaps offer reliable coverage with good blood supply. These flaps are beneficial for their aesthetic outcomes and lower donor-site morbidity compared to muscle flaps. A popular example is the reverse sural artery flap, which requires thorough pre-operative vascular evaluation, particularly regarding peroneal arterial blood flow. Understanding these flaps' dependence on specific blood vessels is crucial to avoid complications such as venous congestion.

Complex Techniques: Muscle and Free Flaps: In cases requiring more robust support, muscle flaps provide substantial vascularity and bulk, making them suitable for covering exposed or infected bone. Despite their benefits, muscle flaps are limited in the foot and ankle due to their small size and rotation arc. It's critical to understand muscle flap classification based on vascular supply to ensure success.

Free flaps represent the most complex reconstructive option, reserved for intricate cases and often necessitating a multidisciplinary team. They involve transferring tissue with its vascular supply to a recipient site, usually requiring vascular anastomosis, making them suitable for severe defects where simpler methods are inadequate.

Surgical Planning and Techniques

Successful management of Charcot soft tissue complications heavily relies on comprehensive



Source: Suh YC, Suh HP, Hong JP. Soft-Tissue Injury. In: Hong SK, Kim D, Jeon S. (eds) Primary Management of Polytrauma. Springer, Singapore. https://doi.org/10.1007/978-981-10-5529-4_8. ©2019.

surgical planning. Selecting incision sites that respect the patient's unique vascular anatomy is paramount. Utilizing the concept of angiosomes and choke vessels–natural blood pathways–ensures optimal blood flow to healing tissues. For this reason, incisions are ideally placed within angiosomes, avoiding areas with compromised blood supply.

Minimally Invasive Surgery (MIS) techniques are also recommended to minimize incision size, which can reduce subsequent soft tissue complications. In addition, pre-operative planning should address any underlying biomechanical issues to prevent recurrent soft tissue breakdown. Proper assessment and staging of existing infections, through clinical examination and appropriate imaging, ensure that surgical interventions are appropriately timed and likely to succeed. By integrating these considerations, surgeons can effectively manage soft tissue complications, ultimately enhancing patient recovery and reducing the risk of recurrence.

A Comprehensive Approach

Managing Charcot soft tissue complications demands a multifaceted and systematic approach that emphasizes prevention, assessment, and strategic intervention. Proactively optimizing a patient's overall health–including managing comorbid conditions, conducting comprehensive lab and vascular workups, and ensuring smoking cessation–lays a solid foundation for minimizing complications. When soft tissue issues arise, assuming and thoroughly evaluating for infection is critical, utilizing advanced imaging, lab tests, and biopsy/cultures to confirm the presence and nature of infections.

The concept of the "reconstructive elevator" guides clinicians in selecting appropriate interventions, beginning with simpler techniques such as dermal grafts and local cutaneous flaps, and progressing to more advanced methods like fascial cutaneous or free flaps when necessary, allowing movement to the most appropriate treatment even if it is more advanced. Addressing underlying biomechanical problems is crucial for the success of soft tissue repair and to prevent recurrence. By employing careful

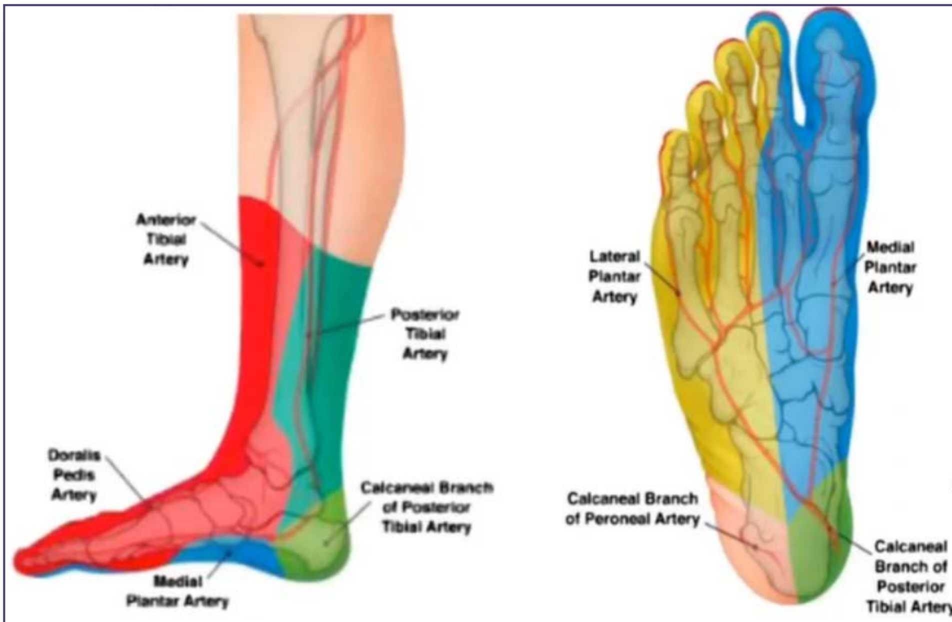


Fig. 1 – Angiosomes of the foot [1]. The a embed.sequel.io is sharing your screen. Stop sharing Hide eries are the three below-knee arteries. The anterior tibial becomes the dorsalis ial gives off calcaneal (heel), and the medial and lateral plantar (sole) branches. The peroneal also contributes a calcaneal branch.

surgical planning, which includes precise incision placement and the potential use of MIS, healthcare providers can achieve optimal outcomes in managing Charcot neuroarthropathy complications.

Kelsey J. Millonig, DPM, MPH, FACFAS, is double-board certified fellowship trained foot and ankle surgeon with the East Village Foot and Ankle Surgeons in Des Moines, IA. She completed her medical education at Des Moines University earning dual degrees in Doctor of Podiatric Medicine and Masters in Public Health. She was the first podiatrist in the world to be selected as a research intern at the World Health Organization Headquarters in Geneva, Switzerland. Dr. Millonig completed her surgical residency at Franciscan Foot and Ankle Institute in Seattle, WA. She then completed her complex deformity correction and orthoplastic reconstructive fellowship at the Rubin Institute of Advanced Orthopedics International Center for Limb Lengthening in Baltimore, MD.

Dr. Millonig has served as a global health medical missionary in several countries including the Yucatan Crippled Children's Project and Uganda Clubfoot Care Project. She is also a fellow member of the International Foot & Ankle Foundation. She has authored multiple articles in medical journals and textbooks. Dr. Millonig frequently lectures nationally, has earned several scholarly awards, and held multiple leadership positions in numerous national podiatric and public health committees with the American College of Foot and Ankle Surgery, American Public Health Association, American Podiatric Medical Association, and American Association for Women Podiatrists.

Dr. Millonig offers expertise in limb deformity correction and limb lengthening including congenital and pos-traumatic conditions, orthoplastic reconstruction, nerve injury, minimally invasive surgery, and neuropathic limb salvage.

Utilizing the concept of angiosomes and choke vessels—natural blood pathways—ensures optimal blood flow to healing tissues.

Lower Extremity Injuries Caused by Falls Treated at Hospital Emergency Departments

By Mathias B. Forrester, BS

Background: Falls are a major public health concern, causing millions of injuries in the United States (US) each year. A portion of injuries caused by falls are likely to involve the lower extremity. The objective of this study was to describe lower extremity injuries caused by falls treated at US hospital emergency departments (EDs).

Methods: Data were obtained from the National Electronic Injury Surveillance System-All Injury Program (NESS-AIP). NEISS-AIP collects data on all types and causes of nonfatal injuries treated in a stratified random sample of 66 US hospital EDs. National estimates are calculated from database records according to the sample weight assigned to each case based on the inverse probability of the hospital being selected for the NEISS-AIP sample. Cases were all records during 2005–2022 where the precipitating cause of injury was a fall and primary body part affected was the lower extremity. For the selected variables, the distribution of the national injury estimates was determined.

Results: An estimated 30,591,246 lower injuries caused by falls were treated at US hospital EDs during 2005–2022 representing 20% of the estimated total injuries caused by falls. The injured body part was 34.5% knee, 28.6% ankle, 15% lower leg, 12.4% foot, 6.8% upper leg, and 2.8% toe. The diagnosis was 33.2% strain or sprain, 27.6% fracture, 24.3% contusion or abrasion, 5.9% laceration, and 8.9% all other. Patients age 65 years and older accounted for 21.2% of the injuries. The patients were 61.7% female and 38.3% male. The location of the incident was 39.6% home, 15.3% other public property, 6.2% place of recreation or sports, 3.4% school, 3% street or highway, 1% industrial place, 0.2% farm or ranch, and 31.3% unknown location.

Conclusion: An estimated 1.7 million lower extremity injuries caused by falls were treated at US hospital EDs annually during the last 18 years. The results of this study may be useful for creating strategies to prevent lower extremity injuries caused by falls.

Falls are a major public health concern. A US health survey in 2008 found that 11.9% of the community-dwelling adults who responded reported falling in the previous year, resulting in an estimated 80 million falls.[1] A 1990 mail-back questionnaire involving adults age 20–87 years observed that 20% of respondents reported falling within the past 12 months, with 8% reported falling multiple times.[2] In a 1996–2001 study in California involving individuals age 45 years or older, 23% reported falling in the past year.[3]

Falls result in millions of injuries in the US each year. The Centers for Disease Control and Prevention (CDC) Vital and Health Statistics reported 9.8 million fall-related injuries among US adults in 2012.[4] In the national health survey, 1% of community-dwelling adults reported a fall-related injury in the prior 3 months, translating to approximately 9.9 million fall-related injuries annually.[1] In the mail-back questionnaire, 8% of the people who fell fractured a bone.[2] As a consequence, annually millions of people in the US are treated in emergency departments (EDs) hundreds of thousands are hospitalized, and thousands die from unintentional falls.[5–8]

A portion of injuries caused by falls are likely to involve the lower extremity. The objective of this study was to describe lower extremity injuries caused by falls treated at US hospital EDs.

Methods

This retrospective epidemiologic study used data from the NESS-AIP. The NEISS-AIP has previously been described in detail in *Lower Extremity Review*.[9] To summarize, the NEISS-AIP collects data on all types and causes of nonfatal injuries treated in a stratified random sample of 66 US hospital EDs. National estimates are calculated from database records according to the sample weight assigned to each case based on the inverse probability of the hospital being selected for the NEISS sample.[10,11] The data are publicly available and de-identified, so the study is exempt from institutional review board approval.

NEISS-AIP data were downloaded from the Inter-university Consortium for Political and Social Research (ICPSR) National Archive of Criminal Justice Data (NACJD) website: www.icpsr.umich.edu/web/NACJD/search/studies?q=national%20electronic&

Cases were all records during 2005–2022 (the most recent year of available data) where the precipitating cause of injury was a fall (Field name PCAUSE_C with numeric value 6 [Fall]) and the primary body part affected was the lower extremity (Field name BDYPT with numeric values 35, 36, 37, 81, 83, 93).

The following variables were examined: primary body part affected, diagnosis (type of injury) associated with the body part, year and month of treatment, patient disposition, location of the incident, and patient age and sex. The NEISS-AIP database contains 2 sets of fields for documenting the diagnosis and associated body part; however, only 1 set of fields was used throughout the study period–DIAG and BDYPT. (The second set of fields–DIAG2 and BDYPT2 appears to have been added in 2018.) For consistency, the study was limited to the first set of fields.

Analyses were performed using Microsoft 365 Access and Excel (Microsoft Corporation, Redmond, Washington). For the selected variables, the distribution of the national injury estimates was determined. National injury estimates were calculated by summing up the values in the WEIGHTA numeric field in the NEISS-AIP database. The US Consumer Product Safety Commission (CPSC), which operates the NEISS-AIP, considers an estimate unstable and potentially unreliable when the estimate is <1,200.[12]

Results

An estimated 30,591,246 lower injuries caused by falls were treated at US hospital EDs during 2005–2022, or an estimated average of 1,699,514 lower extremity injuries per year. This represents 20% of the estimated 152,634,485 total injuries caused by falls. Also, of the 23 different primary cause of injury grouping in the NEISS-AIP database, the highest proportion (30%) of the estimated 101,930,949 total lower extremity injuries treated at US hospital EDs during 2005–2022 were caused by falls.

Figure 1. Annual estimated number of lower extremity injuries caused by falls, National Electronic Injury Surveillance System-All Injury Program

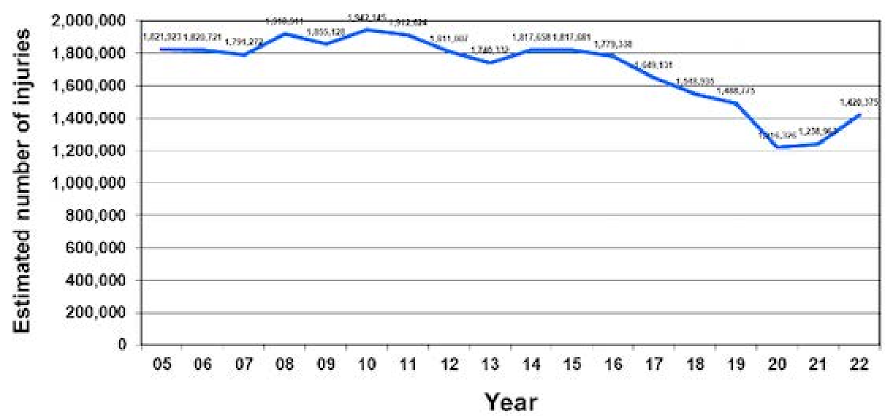


Figure 1 shows the annual estimated number of lower extremity injuries caused by falls. The estimated number of injuries increased 6.6% between 2005 and 2010 before declining 37.4% between 2010 and 2020 before increasing 16.8% between 2020 and 2022. The largest percent decline between 2 consecutive years was an 18.3% decline between 2019 and 2020. The largest percent increase between 2 consecutive years was a 14.6% increase between 2021 and 2022. There were an estimated 7,477,317 (24.4%) lower extremity injuries treated in January–March, 7,798,652 (25.5%) in April–June, 8,038,167 (26.3%) in July–September, and 7,277,111 (23.8%) in October–December.

Table 1 shows the age distribution of lower extremity injuries caused by falls. Patients age 65 years and older accounted for 21.2% of the injuries. The patients were 18,879,055 (61.7%) female, 11,711,226 (38.3%) male, and 965 (0%) unknown sex. The location of the incident was 12,112,607 (39.6%) home (including manufactured or mobile home), 4,685,289 (15.3%) other public property, 1,906,146 (6.2%) place of recreation or sports, 1,043,531 (3.4%) school, 928,282 (3%) street or highway, 293,707 (1%) industrial place, 55,524 (0.2%) farm or ranch, and 9,566,160 (31.3%) unknown location.

The injured body part was 10,556,758 (34.5%) knee, 8,741,031 (28.6%) ankle, 4,575,965 (15%) lower leg, 3,793,115 (12.4%) foot, 2,072,803 (6.8%) upper leg, and 851,574 (2.8%) toe. The diagnosis was 10,148,359 (33.2%) strain or sprain, 8,455,680 (27.6%) fracture, 7,437,891 (24.3%) contusion or abrasion, 1,818,364 (5.9%) laceration, and 2,730,952 (8.9%) all other. The patient disposition was 26,986,909 (88.2%) treated or examined and released from the ED, 2,961,062 (9.7%) treated and admitted for hospitalization (within same facility), 344,981 (1.1%) transferred to another hospital and released, 121,035 (0.4%) held for observation (includes admitted for observation), 176,520 (0.6%) left without being seen or left against medical advice, and 740 (0%) unknown.

Discussion

Falls caused an estimated 30 million lower extremity injuries treated at US hospital EDs during 2005–2022. Furthermore, 20% of all injuries caused by falls involved the lower extremity, and 30% of all lower extremity injuries were caused by falls. Taken together, this indicates that falls are a major cause of lower extremity injuries.

The estimated number of lower extremity injuries caused by falls declined over a large portion of the study period–2010–2020. This decline may be due to efforts to reduce the risk of falls. Alternatively, individuals who were injured due to falls may have become more likely to seek treatment at facilities other than hospital EDs.

Of note, the greatest percent change from 1 year to the next was a 18.3% decline between 2019 and 2020. This large decline may be due to the COVID-19 pandemic declared in March 2020 and the societal disruptions associated with the COVID-19 pandemic.[13] Numerous studies have reported changes in the number of illnesses and injuries because of the COVID-19 pandemic.[14–18] The risk of injuries due to falls might have declined because of the changes associated with the COVID-19 pandemic. Another potential explanation is that the number of injuries due to falls might not have changed greatly but people might have been reluctant to seek treatment at hospital EDs over concern of contracting COVID-19. The increase in the estimated number of lower extremity injuries caused by falls during 2021 and 2022 suggests that, as people increasingly returned to pre-COVID-19 pandemic behaviors, their risk of injury due to falls–or tendency to visit a hospital ED to seek treatment for such injuries–was returning to normal. Still, the annual estimated number of lower extremity injuries caused by falls in 2022 was still lower than that in 2019.

Older adults (age 65 years and older) are at increased risk of falls and fall-related injuries.[1,7,19] This study did not examine the rate of lower extremity injuries caused by falls among the general population. The study did find that patients age 65 years and older accounted for only 21% of the total estimated falls. Most of the patients were female. Previous studies likewise found falls to be more common among females.[1,2,4,19] These observations suggest that fall prevention strategies should include all age groups and that these strategies may need to provide extra focus on females.

Most of the lower extremity injuries caused by falls with a known location of the incident occurred at home. However, the next highest proportion occurred at other public property followed by a place of recreation or sports. This suggests that, while prevention strategies may focus on the home, the strategies should also include other locations where falls are next most likely to occur.

Strains or sprains accounted for one-third of the diagnoses, with fractures and contusions or abrasions each accounting for an additional one-fourth. In general, these types of injuries might not be considered to require extensive hospital intervention. This study found that 88% of the patients were treated or evaluated and released from the ED. However, an additional 11% of the patients were either admitted to the hospital or transferred to another hospital.

This study has limitations. For most of the study period, only a single diagnosis and affected body part were documented in the NEISS-AIP database. For consistency, the study was restricted to these fields. However, a fall may result in multiple types of injuries affecting 1 or more body parts. Thus, the number of falls that caused lower extremity injuries and were included in this study should be considered a lower estimate. Second diagnosis and body part fields were added in 2018. Even if lower extremity injuries documented in these fields were included in the study, the number of lower extremity injuries would probably still be underestimated.

Furthermore, the NEISS-AIP database only includes data on injuries treated at hospital EDs. Injuries treated elsewhere, such as at home, a physician's office, or an other healthcare facility, would not be included. Injuries treated at these other facilities would provide a clearer picture of

Table 1. Age distribution of lower extremity injuries caused by falls, National Electronic Injury Surveillance System-All Injury Program, 2005-2022

Age (years)	Estimate	Percent
0-4	1,009,734	3.3
5-14	3,797,014	12.4
15-24	4,001,224	13.1
25-34	3,849,069	12.6
35-44	3,679,345	12.0
45-54	4,030,587	13.2
55-64	3,738,035	12.2
65-74	2,787,616	9.1
75-84	2,144,131	7.0
85+	1,553,835	5.1
Unknown	656	0.0
Total	**30,591,246**	

Estimate = Weighted estimate (sum of the WEIGHTA numeric field in the National Electronic Injury Surveillance System-All Injury Program database). The numbers in the WEIGHTA field are not whole numbers but include decimals. As a result of rounding to whole numbers when performing analyses, the sum of the estimates for a given variable might not equal the total. The Consumer Product Safety Commission considers an estimate unstable and potentially unreliable when the estimate is <1,200.

lower extremity injuries caused by falls.

In conclusion, the estimated number of lower extremity injuries caused by falls that were treated at US hospital EDs has declined over the last 18 years. Although patients age 65 years and older are considered at increased risk of fall-related injuries, only 21% of the patients in the study were in this age group. Most of the patients were female. While most of the injuries with a known location of the incident occurred at home, the next-highest proportion occurred at other public property followed by a place of recreation or sports. The information in this study may be useful for creating strategies to prevent lower extremity injuries caused by falls.

Mathias B. Forrester, BS, is an independent researcher in Austin, Texas. Now retired, he has performed public health research for various universities, government programs, and other organizations for 40 years.

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Dirty Truth: #6 Elastic to Plastic: Aging Is More Than a Biological Process–It's a Mechanical One Too

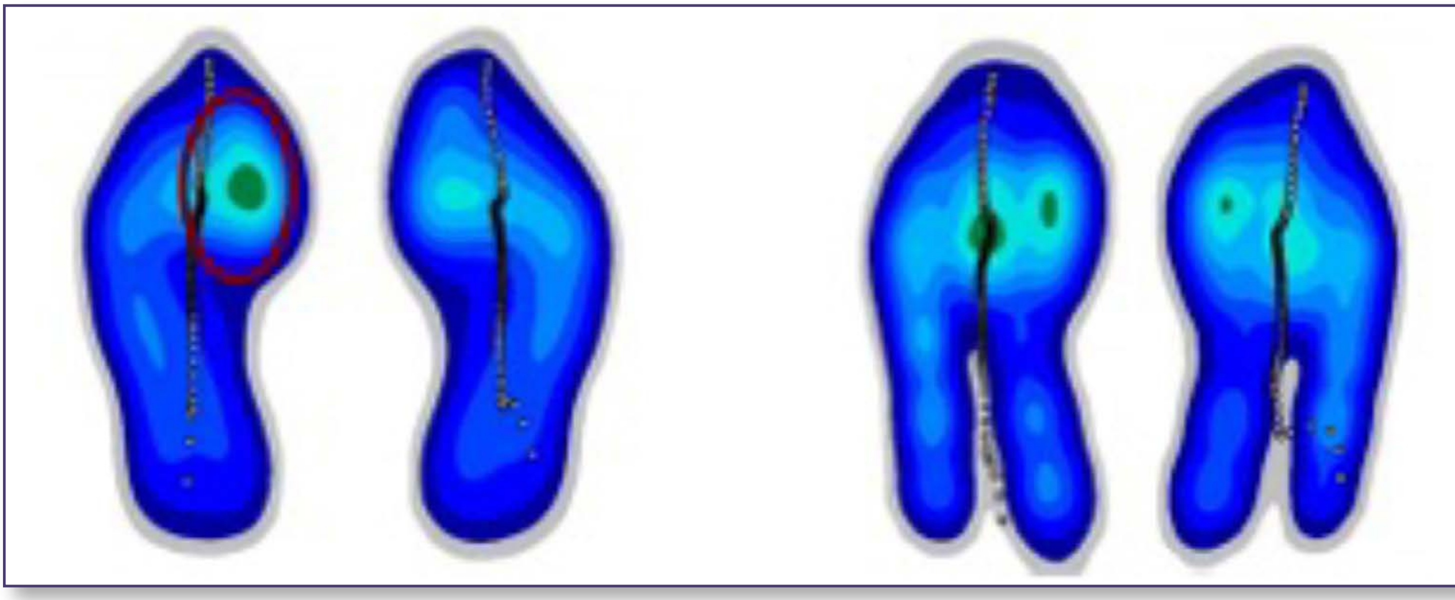


Figure 1: Pressure Plots in bare feet, or even different models of shoes like those shown here, objectively characterize one example of degradation, a great toe bunion. As the toe undergoes lateral deviation and subluxation, the agonist soft tissue structures gain a competitive advantage and tighten down, while the antagonistic soft tissues stretch to lose their straight position.

By Jay Segel, DPM; Sally Crawford, MS

We all know we will not live forever, but perhaps a good goal would be to not outlive your health. We also know that there are elements of our health we can control and those we can't. Aging is a simple fact, though we often don't consider it at the functional microscopic level. We can't do much about the ending, but we have much to say and do about the journey, or the progression of aging. This dirty truth deals with the fallout from the cumulative effects of our past dirty truths as visited upon our soft tissue structures, which, in turn, leads to wear and tear.

Take, for instance, the stretching of a rubber band. New, out of the package, it expands and contracts; we call that property elasticity. As the material ages, it loses the ability to expand and contract to the degree it once did. We might call that loss, aging, or fatigue. Eventually, the integrity of the "rubber" material is rendered unusable and will break if pushed. It's useful to think of this vulnerability to breakage as plasticity, the property of a material going through a permanent, or non-reversible, change in shape. This is what use and/or injury does to our ligaments, which are in a constant state of degradation. (Figure 1)

Computer Aided Gait Assistance (CAGA) tools help identify where excessive force or underloading occurs. For example, the midfoot area may begin to show signs of excessive pressure due to altered posture, possibly from weakened muscles or joint stiffness. Similarly, forefoot pressure might increase as a result of compensation or reduced mobility in the heel or ankle. This overall CAGA data, especially when analyzed over multiple steps, helps reveal patterns that might not be evident from a single stride but are crucial for understanding how soft tissue structures respond to the aging process. (Figure 2)

Another critical metric to help characterize the repetitive nature of impacts is the force-time curve, which measures the total force exerted by the foot during each step, as well as how that force is distributed over time. (Figure 3) Aging often leads to changes in the peak force generated during gait and alterations in how long the foot stays in contact with the ground. For example, a less efficient push-off, common in aging adults, might result in a smaller peak force and longer ground contact time, signaling a decrease in propulsion efficiency. (Figure 3) These changes, when tracked over time, offer valuable insights into how the body compensates for age-related declines in strength, flexibility, or joint integrity.

Repetitive impact, as it relates to gait, is a linear equation. Swing step leads to impact, which is a collision causing a ground force reaction that deforms the foot structure, whose breakdown results in tissue fatigue, asymmetry, wear, heat, inflammation, trauma, scarring, degenerative joint disease, and eventual system breakdown. Repetitive impact devolves to repetitive trauma, which is next up on our "Dirty Truths" playlist. ler

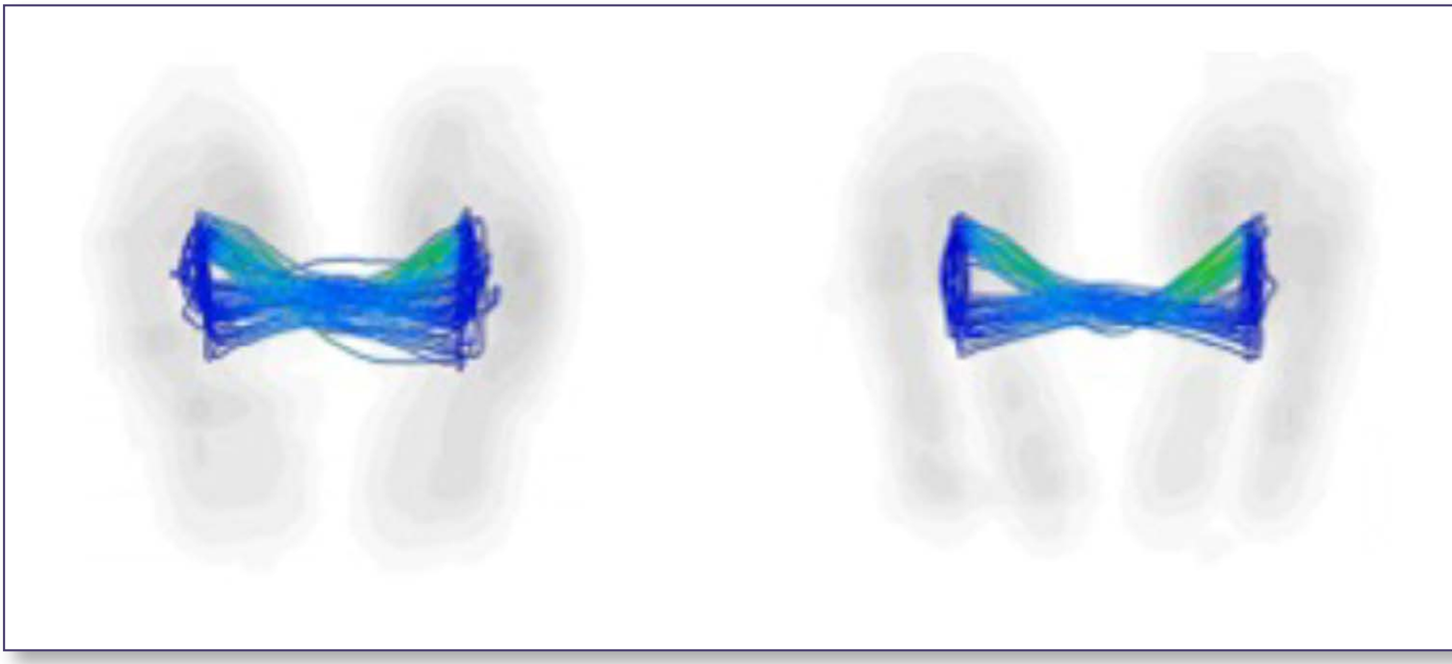


Figure 2: As 1 side of the body weakens or compensates, gait becomes uneven, leading to additional strain on certain joints and muscles. The butterfly diagram and multi-step averaging features, shown here, allow clinicians to assess whether these imbalances are consistent over time or sporadic, providing a more accurate picture of a person's gait stability and potential risk.

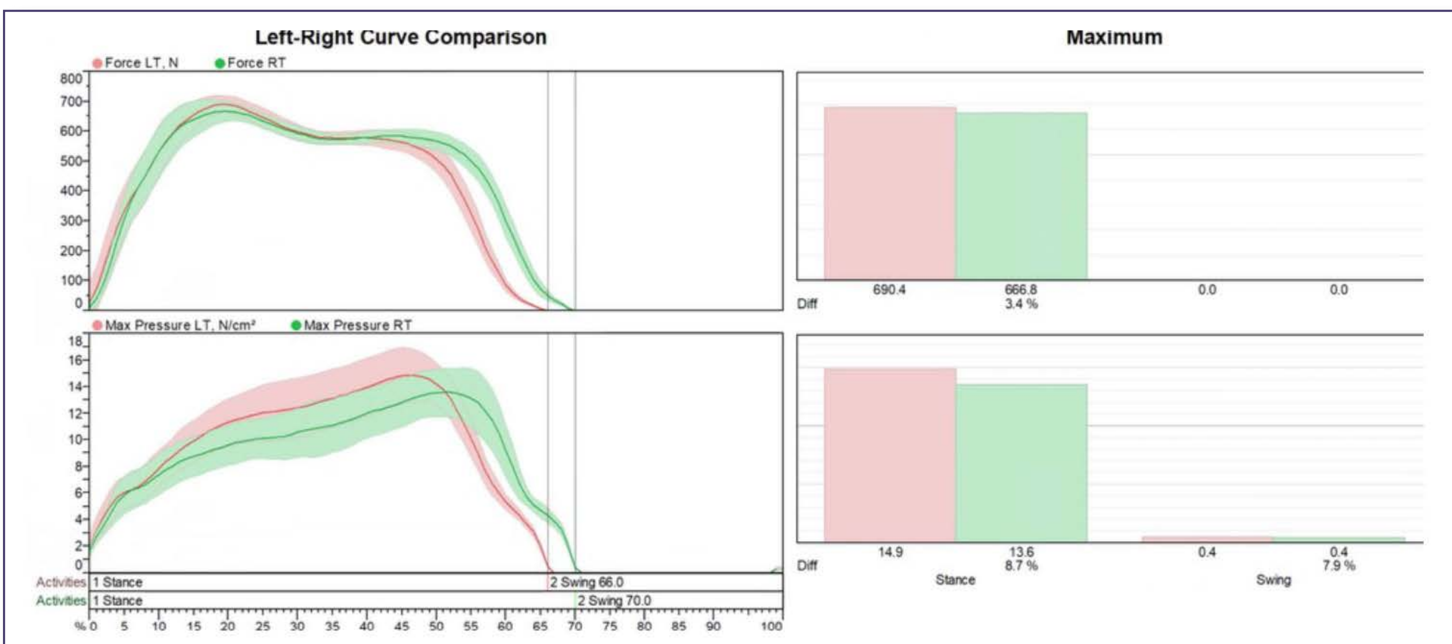


Figure 3: Consistency in force, pressure, and timing data across 45 steps, normalized to 100% gait cycle, reveal underlying imbalances and inefficiencies that might otherwise go unnoticed.

INNOVATIONS IN BIOMECHANICS

3D Scanning vs. Plaster Casting: Evolving Techniques in Orthotic Capture

By Dr. Dean Hartley (Podiatrist & Adjunct Engineering Fellow–University of Queensland)

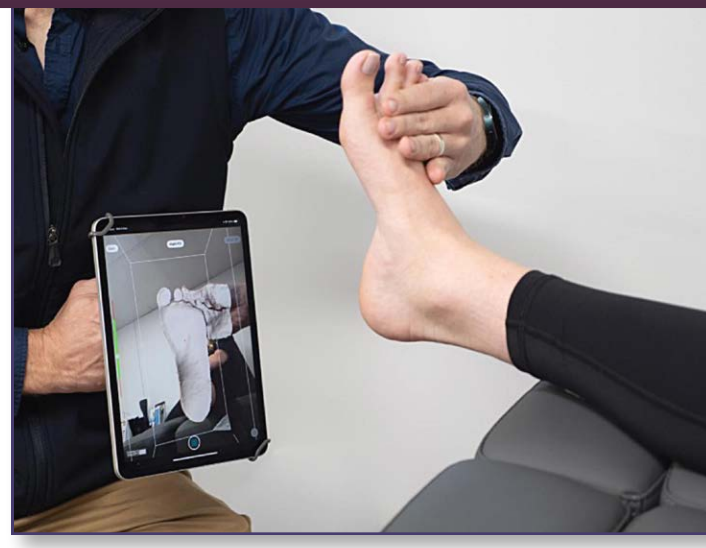
Over the last few decades, clinicians have debated the merits of traditional plaster casting versus modern 3D scanning in orthotic capture. Amid continuing discourse, 1 principle holds: the clinician's grasp of anatomical data and its impact on device design is critical to success. Equally as vital is the orthotic lab's role in translating clinical intent into design. As modern techniques introduce greater variability, the shared responsibility between clinician and lab becomes paramount to achieving successful clinical outcomes.

Today's capture methods span plaster casting, foam boxes, flatbed laser scanning, and increasingly, mobile devices like iPads and iPhones using TrueDepth infrared arrays, structured light, and photogrammetry. Each scanning modality offers unique biomechanical implications. Some clinicians use fully corrected scans via glass/acrylic frames or weight-bearing flatbed techniques to balance forefoot-rearfoot alignment. These approaches often differ from traditional neutral position casting, reflecting a broader shift in clinical philosophy. We're seeing a deliberate evolution in technique–clinicians now over- or under-correct based on individual patient needs, rather than defaulting to neutral.

Others prefer non-weight-bearing scans with minimal correction, trusting the lab to refine the design. Semi-weight-bearing methods such as suspension or prone casting–whether with plaster bandage or handheld scanners–continue to be reliable and widely used. This diversity demands that orthotic labs elevate their clinical literacy. Understanding the nuances of each technique is essential to delivering optimal outcomes. Modification and design must be informed by a deep appreciation of the biomechanical intent behind the capture.

As with any transformative technology, the adoption of 3D scanning in clinical practice brings both opportunity and complexity. At the forefront is the imperative for clinicians to not only understand the mechanics of scanning but to master their techniques ensuring precision, consistency, and excellent patient outcomes.

This theme will be explored in the remaining two articles of this series, which will delve into the current hardware landscape, present findings from a recent comparative study on scan accuracy and offer practical strategies for refining scanning protocols in clinical settings.



Pros & Cons

Technique	Pros	Cons
Traditional/ Plaster Casting	• Easy to balance and visualize • Inexpensive initial outlay • Physical cast for technicians to work from	• Labor intensive Reproducibility • Turnaround times • Inaccuracy of plaster mods • Material warp • Slow and messy casting • Potential damage in post • Costs and time per cast • Foot often shorter/narrower (NWB)
3D Scanning	• Turnaround times • Reproducibility • Accuracy • Scanning speed • Scanning costs become cheaper over time	• More expensive initial outlay • New technique to learn • No physical mold to examine

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The Ground Truth: Foot & Ankle Unlocked **is a bold, monthly exploration of foot and ankle anatomy, biomechanics, and clinical pathology–where foundational science meets modern medicine.**

The Ground Truth isn't just clinical, anatomy-driven–it's education elevated, surgery informed, and innovation inspired. For podiatrists, orthopedic specialists, educators, and students alike, this is where lower extremity excellence begins–one structure, one pathology, one breakthrough at a time.

Melted Boundaries: Regenerative Orthobiologics in Lower Extremity Medicine–The Rise of Orthokine® (Autologous Conditioned Serum) and Enhanced PRP Therapy for Joint Pain

By Dr. Hooman Mir, DPM, MSci, FAPWCA
UTRGV, School of Podiatric Medicine
Department of Podiatric Medicine, Surgery & Biomechanics

Orthokine® is the proprietary name for a German-developed autologous conditioned serum (ACS) therapy now advanced in musculoskeletal medicine for joint pain. In scientific literature and clinical contexts, Orthokine is used interchangeably with the generic designation autologous conditioned serum (ACS), with PubMed-indexed authors favoring ACS for generalizability. This distinction matters for practitioners and researchers tracking the evolution and efficacy of biologics in orthopedic settings. This article reviews the history, science, clinical application, advanced techniques, and safety outcomes for ACS (Orthokine) and enhanced platelet-rich plasma (PRP) therapies—emphasizing their transformative role in lower extremity joint care.

Historical Evolution of PRP and ACS

PRP was originally developed in the mid-20th century for hematologic treatments, then gained traction in surgery, wound care, and orthopedics through the 1980s–1990s. Activated platelets release growth factors and cytokines accelerating tissue repair. In Germany during the late 1990s, Orthokine emerged as the leading ACS approach—where patient blood is incubated with glass beads, creating serum highly enriched in anti-inflammatory agents, especially interleukin-1 receptor antagonist (IL-1Ra). Today, both PRP and ACS form the pillars of biologic therapy in osteoarthritis and sports injuries.

Science and Physiology

Growth Factors, Cytokines, and Mechanisms

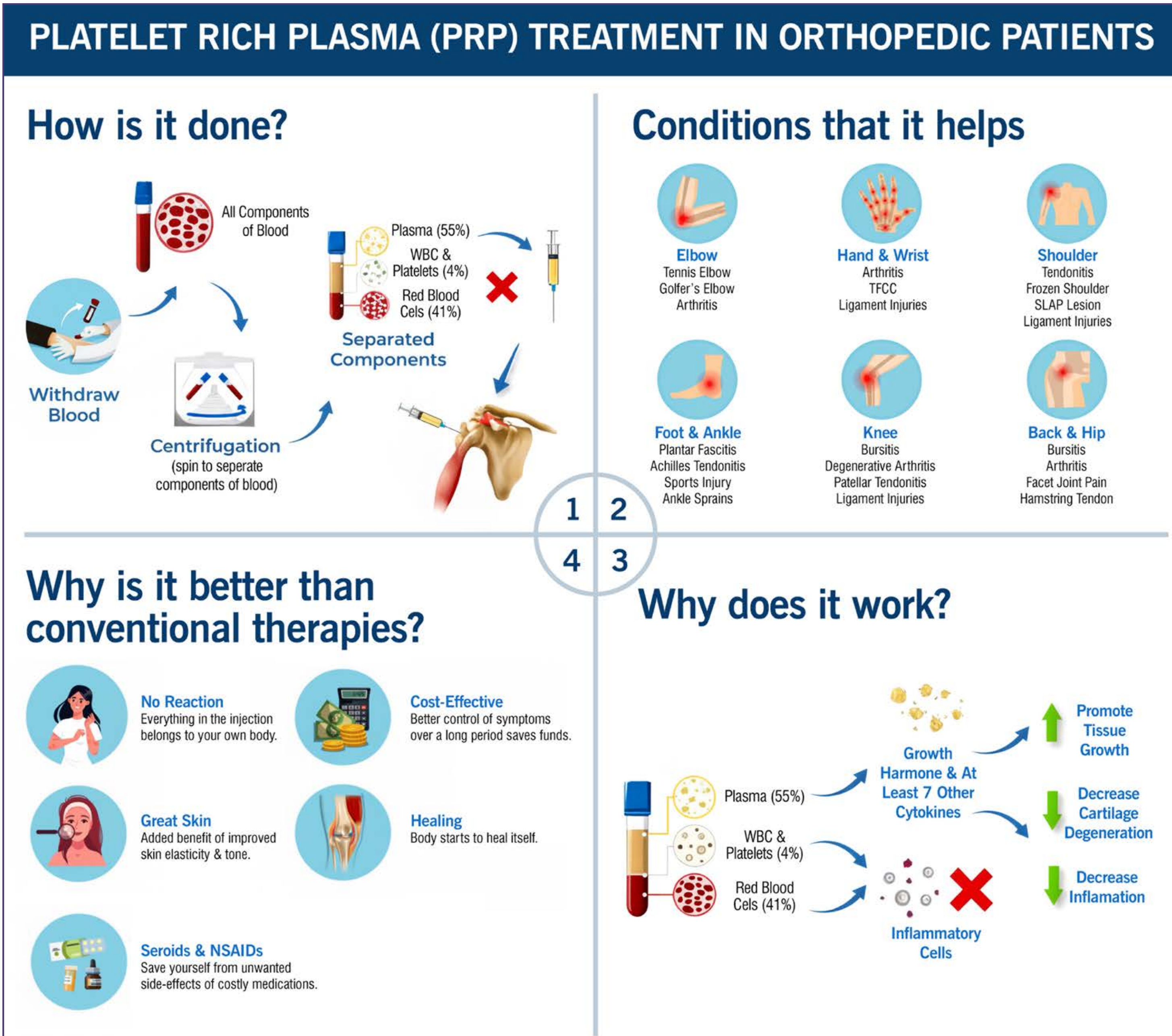
Platelets—and monocyte incubation with glass beads—produce key molecules for healing:

PDGF, IGF-1, TGF-β, VEGF, EGF and IL-1Ra (Orthokine/ACS focus)

Orthokine/ACS magnifies IL-1Ra and growth factors, directly suppressing cytokine-driven joint degeneration.

Table 1. Cytokine and Growth Factor Concentrations in PRP vs. ACS (Orthokine)

FACTOR	PRP (PG/ML)	ACS/ORTHOKINE (3H) (PG/ML)	ACS/ORTHOKINE (24H) (PG/ML)
PDGF-BB	2,035	9,513	10,383
IGF-1	43,791	64,725	72,194
IL-1Ra	158	903	5,689
TNF-α	3.9	10.6	53.5



Clinical Applications in the Lower Extremity

Knee Joint

PRP and ACS/Orthokine therapy are established for knee osteoarthritis, with meta-analyses and RCTs showing pain relief, functional improvement, and patient satisfaction exceeding that of hyaluronic acid and corticosteroids.

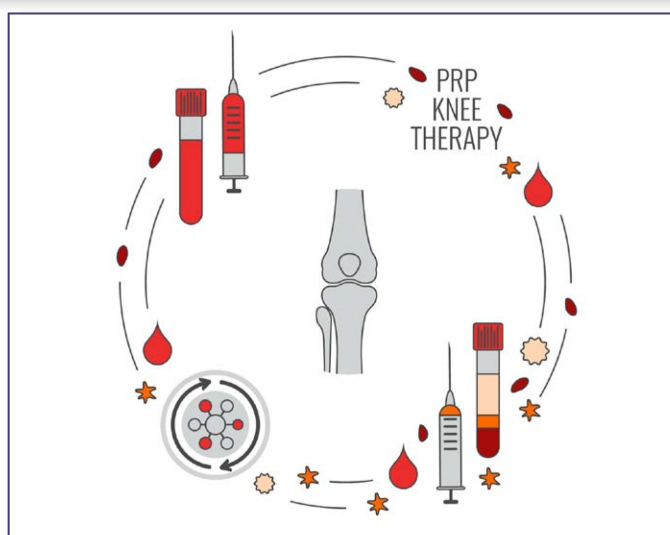


Figure: Schematic representation of platelet-rich plasma (PRP) knee therapy. The image shows blood collection, centrifugation to concentrate platelets, and targeted injection into the knee joint for regenerative treatment of joint pain.

Table 2. ACS (Orthokine) vs. PRP Outcomes for Stage III Knee Osteoarthritis

TREATMENT	MEDIAN PAIN VAS REDUCTION	EARLY IMPROVEMENT (%)
PRP	-4.0	80
Orthokine	-5.0	10

Figure: Clinical administration of platelet-rich plasma (PRP) therapy for knee osteoarthritis. A physician in sterile technique injects PRP directly into the knee joint to promote tissue regeneration and reduce pain.

Ankle Joint and Sinus Tarsi

ACS and PRP are expanding to ankle OA, osteochondral lesions, and sinus tarsi syndrome—where inflammation predominates after trauma.

- Sinus tarsi syndrome: PRP/ACS are as effective as steroid and ozone, with better durability of relief.
- Osteochondral talar lesions: PRP/ACS used as stand-alone or with scaffolds, resulting in functional and imaging improvements.
- Chronic ankle instability: PRP speeds symptom reduction and rehabilitation outcomes.

Table 3. PRP/ACS Outcomes in Lower Extremity Pathologies

CONDITION	COMPARATOR	OUTCOME MEASURES	DURATION
Knee Osteoarthritis	HA, Placebo	WOMAC, VAS	1–12 months
Sinus Tarsi Syndrome	Steroid, Ozone	VAS, AOFAS	1–6 months
Osteochondral Lesion (Talus)	Surgery, HA	Pain, MRI, AOFAS	up to 36 mo
Chronic Lateral Instability	Baseline	Symptoms, Function	6 months

Figure: Platelet-rich plasma (PRP) injection for ankle joint pathology. The procedure involves delivery of PRP into the ankle region to support healing of musculoskeletal injuries and reduce pain in conditions such as tendonitis or osteoarthritis.

Most Advanced and Innovative Techniques

Contemporary ACS/Orthokine and PRP care utilizes:

1. Ultrasound-guided injections for precise delivery intra- or peri-articularly.
2. Custom ACS conditioning protocols (varying incubation, dosing).
3. Combination treatment (PRP + hyaluronic acid/scaffold).
4. Disease-modifying approaches for early-stage OA.

Figure: Preparation of platelet-rich plasma (PRP) for therapeutic use. A technician places a blood sample into a centrifuge to separate components and concentrate platelets, a critical step in producing PRP for joint injections.

Safety, Risks, and Limitations

PRP and ACS have strong safety records. Reported adverse events are rare but happen (refer to table 4).

Table 4. Adverse Events Associated with PRP and ACS/ Orthokine

ADVERSE EVENT	FREQUENCY	CLINICAL EXAMPLES
Infection	Occasional	Septic arthritis
Inflammatory Flare	Occasional	Severe synovitis
Allergic Reaction	Rare	Rash, serum sickness
Subcutaneous Nodule	Very rare	Granuloma (cosmetic/facial)
Blindness	Extremely rare	Cosmetic/facial vascular occl.

Carefully controlled preparation and patient screening are essential to minimize risks and optimize efficacy.

Dr. Hooman Mir, DPM, MSci, FAPWCA, is a Tenure-Track Assistant Professor of Medicine and Faculty Senator at UTRGV School of Podiatric Medicine. Dr. Mir is an alumnus of Temple University School of Podiatric Medicine and completed his surgical internship at Mount Sinai Hospital in New York. Dr. Mir's commitment to podiatric academic medicine is defined by a series of distinctive firsts: the first Doctor of Podiatric Medicine (DPM) to receive full NIH tuition reimbursement for a Master of Science in Clinical Investigation at UT Health San Antonio; the first DPM to graduate from Harvard Medical School's prestigious T2T Program; the first DPM and only faculty member in the UTRGV Health System inducted into the historic Harvard Club of Boston; and the first DPM at UTRGV Health System ever to be accepted into the School of Medicine's PhD program in Human Genetics—focused on Precision Medicine in Diabetes—now embarking on his second year of doctoral study.

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New & Noteworthy

Noteworthy products, association news, and market updates

XTREME RAPID RELIEF: HEMP CBD FOR ACHY JOINTS

Xtreme Brands Rapid Relief, available as a balm, a spray, and gummies, is designed to target areas where tension tends to build–feet, legs, shoulders, lower back. The balm contains 650 mg of hemp-derived cannabidiol (non-intoxicating CBD) plus a proprietary blend of botanicals including arnica (for tension or strain), turmeric oil (to promote circulation), bromelain (an enzyme to help reduce swelling/support tissue recovery), menthol, camphor, and a blend of botanical oils (willow bark, cinnamon leaf, sage, peppermint). The spray, which contains 500 mg of hemp-derived CBD plus the botanicals, is designed to deliver fast, hands-free support for larger and/or hard-to-reach areas of the body. It's quick-drying and easy to apply. The gummies, which come in natural fruit flavors (black cherry, strawberry, pineapple), contain 25 mg hemp-derived CBD in a vegan gummy base with no THC, no added sugars, no dyes, and no fillers.

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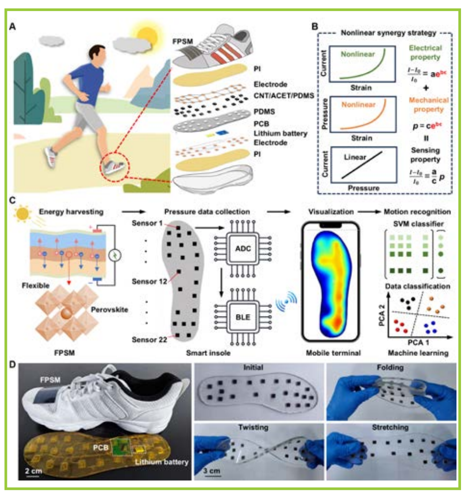
SMART INSOLE TRACKS HOW YOU WALK, RUN, STAND

A new smart insole system that uses machine learning to learn and classify 8 different types of motion states, including static ones like sitting and standing to more dynamic movements such as running and squatting, monitors how people walk in real time could help users improve posture and provide early warnings for conditions from plantar fasciitis to Parkinson's disease. That offers opportunities for personalized health management, including real-time posture correction, injury prevention, and rehabilitation monitoring. Customized fitness training may also be a future use, the researchers said.

Constructed using 22 small pressure sensors and fueled by small solar panels on the tops of shoes, the system offers real-time health tracking based on how a person walks. This data can then be transmitted via Bluetooth to a smartphone for quick and detailed analysis, said Jinghua Li, co-author of the study and an assistant professor of materials science and engineering at The Ohio State University (Ohio State).



Overview of the self-powered smart insole.

Li and Qi Wang, a materials science and engineering PhD student at Ohio State, sought to ensure that their wearable is durable, has a high degree of precision when collecting and analyzing data, and can provide consistent and reliable power.

Since the materials the insoles are made of are flexible and safe, the device is low-risk and safe for continuous use. For instance, after the solar cells convert sunlight to energy, that power is stored in tiny lithium batteries that don't harm the user or affect daily activities. Because of the distribution of sensors from toe to heel, the researchers could see how the pressure on parts of the foot is different in activities such as walking versus running.

According to the study, these smart insoles showed no notable deterioration in performance after 180,000 cycles of compression and decompression, showing their long-term durability.

KNEE RESURFACING SYSTEM

The OvertureTi Knee Resurfacing System is composed of femoral and tibial implants intended to be used in the partial replacement of the articular surfaces of the knee. These implants were designed with sizing options that allow the surgeon to replace only the diseased or damaged region of the joint while preserving healthy surrounding cartilage and meniscus. The procedure is referred to as Focalplasty®. The implants' baseplates are 3D printed, porous titanium to promote osseointegration and solid fixation. Articulating surfaces for the femoral and tibial components are titanium nitride, and an over-molded Vitamin E treated, highly crosslinked polyethylene, respectively. The implants are designed specifically as an alternative when biological repair options are not viable for treating focal cartilage lesions and come with all instrumentation sterile-packed for streamlined, single-use efficiency in the operating room.

Overture Orthopaedics
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TRUNCAL PNEUMATIC COMPRESSION GARMENT

AIROS® Medical recently launched expanded sizing for its truncal garments. These larger garment models grant more patients living with lymphedema-related abdominal and pelvic swelling access to pneumatic compression device-driven compression therapy that reduces edema and pain. These pants-like garments cover the feet, legs, hips, belly, and abdomen, and feature pull handles and O-ring zippers to make applying and removing the garments easy for patients. Air is delivered into the garments' chambers from the compression device at a pressure gradient, moving lymphatic fluid in the correct physiological direction and improving circulation. Six new 8-chamber truncal garment models of varying inseam lengths and abdominal circumferences will now be available for use with the AIROS 8P pneumatic compression device. These garments and device are reimbursed by Medicare and commercial insurances nationwide and are ideal for lymphedema patients with complex swelling conditions.

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DATA-DRIVEN DESIGNS TO IMPROVE PROSTHETIC LEGS

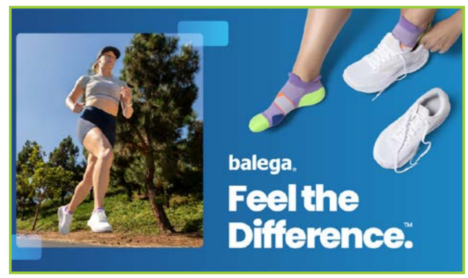
Researchers have developed a new, data-driven way of fitting prosthetic legs, which could lead to better fitting prostheses, in less time and at a lower cost. The technology has been developed by Radii Devices and the University of Southampton, UK. The study shows that transtibial prosthetic limbs designed using the new approach were as comfortable, on average, as those created by skilled prosthetists, and with more consistent results. Crucially, the new method generates a basic design instantly. The team behind the software hopes that data-driven 'socket' designs will reduce the time, number of iterations, and number of appointments it takes to arrive at a prosthetic limb with which the patient is comfortable.

Radii Devices, a spin-out company from the university, has developed software that draws on data from hundreds of previous prosthetic socket designs to generate recommendations for the most comfortable socket shape using a 3D scan of the patient's residual limb. In doing so, they've been able to identify trends between different patient characteristics, such as the shape and size of the residual limb, and successful socket shapes, said Joshua Steer, PhD, founder and CEO of Radii Devices. "We can then scan a patient's residual limb and generate a personalized design recommendation based on features that have been successful for similar patients in the past."

Seventeen patients were given a trial socket designed by a prosthetist and 1 designed using the new method and were asked to compare the comfort of the sockets. The study found there was no difference in the comfort scores on average, and less variation in comfort in the data-driven socket designs. Several participants preferred the fit of the data-driven socket design and had it turned into their definitive prosthesis.

The design recommendations aren't intended to be used on their own in clinical practice. Instead, the researchers envision prosthetists working with the technology to further enhance the patient experience. Now, the software interface is being developed with clinicians to provide them the most effective way to incorporate data-driven socket designs into their practice.

PERFORMANCE SOCKS



Balega performance running socks for runners, athletes, and other consumers living active lives, are available in several styles, sock heights, and designs that offer different levels of cushioning and compression to create a uniquely comfortable performance sock. Balega is known for its innovative design featuring moisture-wicking Drynamix™ yarn, seamless construction, and premium cushioning. This design allows the sock to comfortably fit on the foot while preventing friction and unwanted movement so that users can run, walk, or engage in their favorite activities without any distractions. Popular styles include the UltraGlide, Ultralight, Enduro, and Hidden Comfort. Utilizing the best performance yarns produced across the globe, the socks are crafted for a superior fit and unmatched comfort.

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DREAMCELL® VELO is an ultra-lightweight, poured polyurethane (PU) insole technology engineered to give athletes a powerful edge in speed, agility, and explosive energy return. The product outperforms traditional poured PU insoles with its ultra-lightweight and low compression set engineered to preserve energy transfer, run after run, and game after game. Built for athletes who demand both high performance and sustainability, DREAMCELL VELO's sport-smart design offers an ideal speed-to-comfort ratio–empowering fast, dynamic movement without sacrificing durability or comfort. Feet can stay fresh and cool with the breathable, antimicrobial technology and will stay dry and odor-free with DREAMCELL's moisture-wicking properties.

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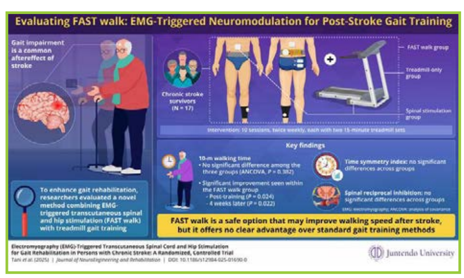
EVALUATING FAST WALK SYSTEM FOR NEUROMODULATION-ASSISTED GAIT RECOVERY IN CHRONIC STROKE

In an effort to address the ongoing challenge of gait impairment after stroke, researchers have developed an innovative rehabilitation approach known as FAST walk, an innovative, electromyography (EMG)-triggered system that synchronizes transcutaneous spinal cord stimulation with hip extensor stimulation. This dual approach uses the patient's own muscle signals to stimulate precisely during key gait phases. By enhancing the spinal circuit excitability and activating reflexes such as the crossed extensor reflex, the system aims to improve lower-limb coordination and gait efficiency. This study was led by Professor Toshiyuki Fujiwara and Dr. Mami Tani from the Department of Rehabilitation Medicine, Juntendo University Graduate School of Medicine, Japan.

To evaluate the clinical potential, researchers conducted a randomized controlled trial involving 3 groups: FAST walk, spinal stimulation alone, and treadmill training. Each group received 2 gait training sessions per week for 5 weeks. All groups demonstrated improvements in walking speed that exceeded the minimum clinically important difference for chronic stroke (0.15 m/s). Specifically, the FAST walk group improved from 0.55 m/s to 0.70 m/s, the spinal stimulation group from 0.90 to 1.16 m/s, and the treadmill group from 0.90 to 1.09 m/s. However, only the FAST walk group showed a statistically significant improvement in gait speed within groups, suggesting that the combined stimulation may offer added benefit over either approach alone.



A novel EMG-triggered system syncs spinal and hip stimulation to boost gait in stroke survivors. Image courtesy of Toshiyuki Fujiwara, Juntendo University.

The study also assessed spinal reciprocal inhibition (RI) as a potential marker of neural modulation. No significant changes were observed, likely due to the measurement being done at rest rather than during gait, where phase-specific modulation would be more pronounced. The use of orthoses in some participants may have further limited voluntary ankle movement, reducing observable RI changes.

Despite these limitations, the study provides early evidence of FAST walk's feasibility, safety, and potential efficacy. The fact that meaningful improvements were observed within a short and constrained intervention window underscores its clinical promise. While additional validation is needed, this study marks an important step forward in integrating neuromodulation into post-stroke rehabilitation.

HIKING BOOTS WITH UPGRADED TECHNOLOGY

The Armadillo 3 is a complete upgrade to one of NORTIV 8's most iconic hikers. Powered by SGS-certified Waterproof-Pro technology, it withstands more than 15,000 dynamic test cycles without seepage, crushing the static standards of its predecessor. A newly engineered outsole with 4 traction zones locks onto mud, rock, and scree with unwavering grip, while a retooled EVA midsole cuts 18% of the weight and delivers 13% more rebound for faster, easier climbs. Durability surges ahead too, with a 30% stronger outsole and superior traction across wet and dry terrain. Reinforced with a TPU skeletal frame, armored toe cap, and secure ankle wrap, the Armadillo 3 isn't just built for the trail–it's built to conquer it.

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ZIMMERMAN SHOES ACQUIRES MARKELL SHOE COMPANY

Zimmerman Shoes, Orwigsburg, Pennsylvania, the United States' oldest manufacturer of children's shoes, has acquired Markell Shoe

Company, Yonkers, New York, an orthopedic and corrective footwear manufacturer. The acquistion enhances Zimmerman Shoes' product portfolio and strengthens its position in the industry. Production of Markell-branded shoes will continue at the Zimmerman Shoes facility in Orwigsburg, ensuring continuity for retailers, healthcare providers, and customers. Financial details of the transaction were not disclosed.

AI-ASSISTED MODEL HELPS IMPROVE PREDICTION OF WORSENING KNEE OA

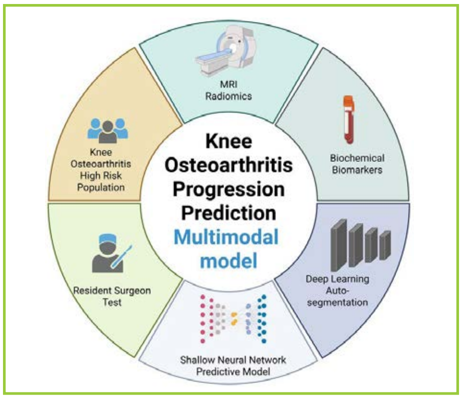

Illustration highlighting the integration of MRI radiomics and biochemical biomarkers for knee osteoarthritis progression prediction. Created with Biorender. Image courtesy of Ting Wang, et al.

An artificial intelligence (AI)-assisted model that combines a patient's MRI and biochemical and clinical information shows preliminary promise in improving predictions of whether their knee osteoarthritis (OA) may soon worsen. Ting Wang of Chongqing Medical University, China, and colleagues utilized data from the Foundation of the National Institutes of Health Osteoarthritis Biomarkers Consortium on 594 people with knee OA including their biochemical test results, clinical data, and a total of 1,753 knee MRIs captured over a 2–year timespan. With the help of AI tools, the researchers used half of the data to develop a predictive model combining all 3 data types. Then, they used the other half of the data to test the model, which they named the Load-Bearing Tissue Radiomic plus Biochemical biomarker and Clinical variable Model (LBTRBC-M).

In the tests, the LBTRBC-M showed good accuracy in using a patient's MRI and biochemical and clinical data to predict whether, within the next 2 years, they would experience worsening pain alone, worsening pain alongside joint space narrowing in the knee (an indicator of structural worsening), joint space narrowing alone, or no worsening at all. The researchers also had 7 resident physicians use the model to assist their own predictions of worsening knee OA, finding that it improved their accuracy from 46.9% to 65.4%.

These findings suggest that a model like LBTRBC-M could help enhance knee OA care. However, further model refinement and validation in additional groups of patients is needed.

ACHILLES REPAIR SYSTEM

Medline UNITE Foot & Ankle's new FORCECORD™ Midsubstance Achilles Repair System is constructed from a densely woven, tubular, synthetic, non-resorbable polyester. The implant features flat tapered ends and uses a specially designed probe for ease of passing. When combined with Medline UNITE's DEXLOCK® Knotless Suture Anchors, the system is intended to offer repair through a streamlined technique. The mechanical bench testing shows FORCECORD has 26% greater ultimate tensile strength and 18% greater pull-out strength compared to traditional 2 mm suture tape. The product is designed to accommodate quicker return to weight bearing as directed by a physician for patients post-operatively. In addition to FORCECORD, Medline's new DEXLOCK Achilles Kit is now available for surgeons using a double row knotless anchor construct for insertional Achilles repairs and Haglund's procedures.

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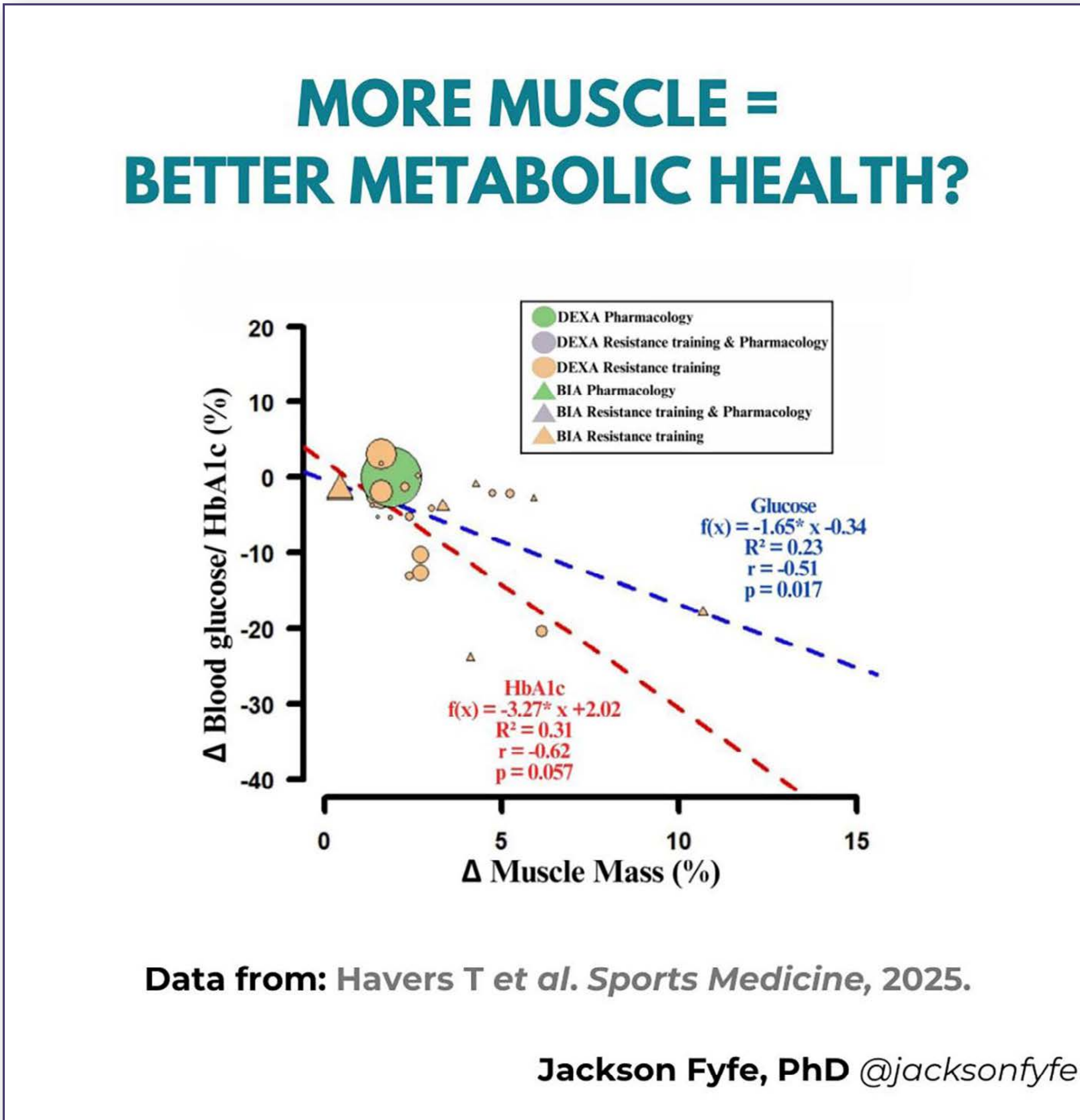
PREMIUM INSOLES FOR EVERYDAY USE AND HIGH-PERFORMANCE ACTIVITIES

Northwest Podiatric Laboratory, a manufacturer of custom orthotics since 1964, has introduced StepCraft® premium insoles–a culmination of 6 decades of biomechanical expertise. The insoles are said to transform movement with unmatched support, stability, and performance. Featuring an ultra-thin composite shell for a seamless fit in any shoe, StepCraft balances strength, lightness, and durability. Premium elements, inspired by custom designs, include a deep heel cup, enhanced rearfoot stability, and antimicrobial top cover. Available in low-, mid-, and high-arch styles, they are designed for daily wear or high-performance activities, without sacrificing comfort or function. Made in Washington State using US and imported materials, StepCraft advances the mission of delivering foot pain solutions for athletes, professionals, and everyday heroes. Healthcare professionals can offer StepCraft now; online sales begin late 2025.

StepCraft
stepcraft.com



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