Low-Dose Radiation Therapy for Refractory Foot Osteoarthritis and Plantar Fasciitis: A Promising Frontier in Podiatric Care.

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Introduction

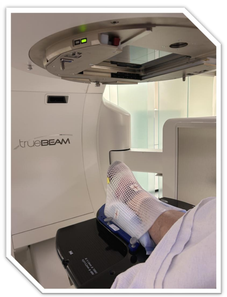
In recent decades, the global landscape of radiation oncology has shifted dramatically, with major advances in cancer prevention, early detection, and targeted systemic therapies contributing to a decline in the overall volume of traditional radiotherapeutic indications. As curative and palliative cancer cases have decreased in relative proportion, radiation departments, particularly in developed healthcare systems, have increasingly explored the re-emergent role of low-dose radiation therapy (LDRT) for benign inflammatory and degenerative disorders.[1] Modern evidence has reaffirmed its potent anti-inflammatory effects at sub-cytotoxic doses, spurring renewed interest in its use for osteoarthritis, enthesopathies, and chronic pain syndromes.[2] This resurgence is partly driven by radiation oncologists seeking to optimize departmental resources, maintain procedural expertise, and expand clinical relevance while addressing the unmet needs of patients with refractory musculoskeletal pain who are poor surgical candidates. The integration of LDRT into multidisciplinary pain and orthopedic care pathways thus represents both a scientific rediscovery and a pragmatic adaptation to contemporary oncology practice.[3]

The therapeutic effects of low-dose radiation therapy (LDRT) in benign musculoskeletal disorders such as osteoarthritis and plantar fasciitis derive primarily from anti-inflammatory and immunomodulatory mechanisms rather than cytotoxic effects.[4] At sub-cytotoxic doses (typically 0.3–1.0 Gy per fraction), LDRT influences the inflammatory microenvironment by altering cellular signaling pathways within endothelial cells, macrophages, and fibroblasts.[5] Experimental studies demonstrate down-regulation of pro-inflammatory cytokines including tumour necrosis factor-α (TNF-α), interleukin-1β (IL-1β), and interleukin-6 (IL-6), alongside up-regulation of anti-inflammatory mediators such as transforming growth factor-β (TGF-β).[6] The therapy also promotes a macrophage phenotype shift from M1 to M2, reduces leukocyte adhesion to vascular endothelium, and attenuates nitric oxide and reactive oxygen species production, collectively dampening chronic inflammatory cascades.[2] In articular and enthesopathic tissues, these effects reduce synovial hyperplasia, fibroblast proliferation, and local edema, leading to pain relief, improved tissue elasticity, and restoration of function.[5] The net result is modulation of inflammation and pain transmission without structural damage, mechanistically distinct from ablative radiotherapy yet highly relevant for chronic degenerative conditions of the foot.[4]

Osteoarthritis and plantar fasciitis represent two of the most challenging and prevalent sources of chronic foot and ankle pain encountered in podiatric clinical practice. Both conditions are multifactorial, progressive, and often resistant to monotherapy.[7] In osteoarthritis, degenerative cartilage loss, subchondral sclerosis, and peri-articular inflammation lead to persistent stiffness and pain that can significantly impair ambulation and weight-bearing tolerance.[7] Plantar fasciitis, conversely, arises from repetitive microtrauma and chronic overload at the calcaneal enthesis, resulting in debilitating heel pain that is frequently most severe upon first steps after rest.[8] Despite a broad armamentarium of conservative interventions, orthotic support, pharmacologic therapy, physical rehabilitation, and injections, a substantial subset of patients experiences refractory or recurrent pain.[7] The chronic nature of these conditions exacts a considerable toll on quality of life, often limiting occupational function, physical activity, and sleep, and contributing to emotional distress or reduced social engagement.[8] For individuals in physically demanding professions, such as healthcare or manufacturing, persistent pain can threaten employment sustainability and independence.[7] The combination of high prevalence, therapeutic recalcitrance, and cumulative functional burden underscores the need for safe, durable, and minimally invasive alternatives such as low-dose radiation therapy within multidisciplinary foot and ankle care.[4]

The application of low-dose radiation therapy (LDRT) to benign musculoskeletal disorders has gained renewed attention in recent years, particularly within European radiation oncology literature.[9] The strongest evidence comes from Germany, where randomized controlled trials and retrospective analyses have demonstrated pain relief rates of 70–90% in conditions such as plantar fasciitis and degenerative osteoarthritis of major joints.[9] These studies, conducted primarily by radiation oncologists, established LDRT's role as a safe, well-tolerated, and biologically active therapy at total doses of 3–6 Gy delivered in 0.5–1.0 Gy fractions.[4] Despite this robust body of evidence, nearly all publications originate from radiation-oncology settings rather than podiatric or orthopedic practices, resulting in a notable gap in specialty-specific evidence.[10]

For plantar fasciitis, German cooperative group studies and multiple randomized trials have confirmed significant and durable reductions in heel pain and functional disability following LDRT compared with very-low-dose regimens or standard injection therapy.[9] Pain reduction typically occurs several weeks after therapy completion and persists for months to years in most responders.[4] However, these studies rarely incorporate podiatric functional metrics and they seldom involve podiatrists as investigators or co-authors. Consequently, the translation of these findings into podiatric clinical protocols remains incomplete.[10]
In contrast, data for foot and ankle osteoarthritis are exceedingly sparse.[11] Most osteoarthritis trials evaluating LDRT focus on knee, hand, or shoulder joints; the few that include the foot or ankle do not report separate subgroup outcomes.[11] No English-language studies to date have systematically analyzed first metatarsophalangeal, midfoot, subtalar, or ankle joint osteoarthritis treated with LDRT.[11] Similarly, there are no prospective, podiatry-led registries or controlled series assessing radiotherapy's role as a limb-preserving or surgery-delaying intervention in degenerative foot disease.[10] This absence of targeted data represents a significant opportunity for podiatric research, particularly in integrating imaging biomarkers (ultrasound fascia thickness, MRI marrow edema) and gait-related endpoints to quantify therapeutic response.[4]
Collectively, the existing literature demonstrates that while LDRT is scientifically validated for its anti-inflammatory effects and has proven efficacy in plantar fasciitis and osteoarthritis of larger joints, its application within podiatric medicine remains largely unexplored. [4]

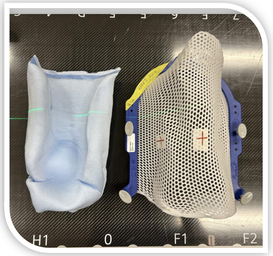


Case Report

Prior to initiation of low-dose radiation therapy (LDRT), all patients underwent comprehensive diagnostic imaging to confirm the extent and location of degenerative or inflammatory pathology. Depending on clinical presentation, a magnetic resonance imaging (MRI) scan and/or computed tomography (CT) of the affected region was obtained to delineate osseous and soft-tissue changes and to assist in treatment planning. Each patient subsequently participated in a radiation oncology consultation, during which the procedure, expected benefits, and potential risks, including transient fatigue, erythema, or extremely low theoretical secondary malignancy risk, were thoroughly discussed, and informed consent was obtained.

Treatment planning was performed using three-dimensional conformal planning software within the Varian Eclipse™ Treatment Planning System (Varian Medical Systems, Palo Alto, CA). Planning CT simulation images were used to construct volumetric treatment fields tailored to the target region while minimizing exposure to adjacent normal tissues. Dose constraints and beam angles were optimized to deliver 0.5 Gy per fraction every other day for a total dose of 3 Gy, in accordance with benign-disease protocols.

On the day of treatment, the patient was positioned in a radiation-shielded treatment room on the linear accelerator table. The affected limb was immobilized using either a custom thermoplastic mold or a Vac-Lok™ vacuum immobilization device to ensure reproducible alignment across all fractions.



Radiation was delivered using the Varian TrueBeam® linear accelerator, employing image-guided verification for precision targeting. Each treatment session typically lasted less than one minute, and all patients tolerated the procedure well without adverse events or interruption in care.

Case 1 – Recalcitrant Bilateral Plantar Fasciitis

A 61-year-old female registered nurse presented for evaluation of chronic bilateral heel pain consistent with plantar fasciitis. The patient reported a long history of symptoms and failure of numerous conservative modalities over several years, including custom orthotics, shoe modifications, oral and injectable corticosteroids, nonsteroidal anti-inflammatory drugs, laser and red-light therapy, physical therapy, acupuncture, massage therapy, chiropractic care, and dedicated stretching programs.

Despite exhaustive conservative management, her pain persisted and was increasingly limiting, particularly in the right heel during 12-hour nursing shifts that required prolonged standing.

Physical examination revealed focal tenderness along the plantar medial calcaneal tubercle and central arch bilaterally, with pain reproduced on passive dorsiflexion of the digits and palpation of the proximal plantar fascia. Ankle dorsiflexion was limited, improving with knee flexion, consistent with gastrocnemius equinus. Mild hallux valgus deformity was observed bilaterally. Neurovascular status was intact to both feet. There was no evidence of edema, erythema, or neurological deficit.

After extensive discussion of remaining treatment options, including surgical plantar fasciotomy, the patient elected to pursue low-dose radiation therapy (LDRT) as a non-invasive alternative. She underwent six radiation sessions administered every other day over two weeks, receiving a total dose consistent with established protocols for benign enthesopathy (0.5–1.0 Gy per fraction; cumulative 3–6 Gy).

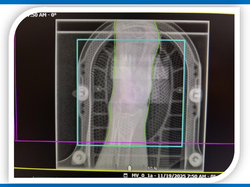
The treatment was well tolerated without adverse cutaneous or systemic effects. Within several weeks of completing therapy, the patient reported complete resolution of heel pain and restoration of full functional activity, including the ability to work full nursing shifts without limitation. At subsequent follow-up, she remained asymptomatic and declined further intervention.

Case 2 – Refractory Bilateral Osteoarthritis of the Foot

A 68-year-old male presented with chronic, progressive left ankle and hindfoot pain associated with long-standing pes planovalgus deformity and posterior tibial tendon dysfunction. He described a lifetime of physically demanding labor and noted that his left foot had "collapsed" in adulthood, resulting in medial arch flattening and inward rolling of the ankle. Conservative measures, including custom orthotics, supportive braces, oral analgesics, and corticosteroid therapy, had failed to provide lasting relief. The patient's medical history was significant for type 2 diabetes mellitus, coronary artery disease with prior stent placement and CABG, hypertension, hyperlipidemia, and a 40-pack-year smoking history. Physical examination demonstrated severe pes planovalgus deformity (left > right), tenderness along the posterior tibial tendon distal to the medial malleolus, limited ankle range of motion, and crepitus of the subtalar and midfoot joints. Radiographs confirmed advanced degenerative joint disease of the left hindfoot and ankle with joint space narrowing, sclerosis, and periarticular osteophyte formation. Given the patient's comorbidities and reluctance to pursue reconstructive fusion, a non-surgical, palliative approach was recommended.

The patient underwent low-dose radiation therapy (LDRT) targeting the left ankle and hindfoot, consisting of six fractions delivered every other day over two weeks (total dose = 3 Gy). Treatment was well-tolerated without adverse effects. Remarkably, by the end of the second week, the patient reported near-complete resolution of pain and restoration of function, returning to full activity without the need for additional bracing or analgesic support. At follow-up, no recurrence of pain was reported, and the patient expressed satisfaction with his outcome.

This case highlights the potential of LDRT as a safe, non-invasive, and function-preserving therapeutic option for patients with advanced degenerative foot and ankle arthritis who are poor surgical candidates. The rapid and durable response observed underscores the need for further investigation into joint-specific applications of LDRT within podiatric practice.



Discussion

From a podiatric perspective, LDRT may represent an intermediate-tier therapy between biologic injections and surgical intervention. It carries practical appeal for patients with poor surgical candidacy or recalcitrant symptoms.

At our facility, a notable shift in case demographics has been observed over the past year with more than half of patients referred for radiation therapy were treated for osteoarthritis or other benign soft tissue conditions rather than malignancy. This reflects an emerging trend in radiation oncology toward non-oncologic applications, aligning with global data that highlight growing interest in low-dose radiation therapy (LDRT) for inflammatory and degenerative diseases. The predominance of benign cases underscores both the therapeutic promise of LDRT and the willingness of radiation oncology departments to reallocate capacity toward quality-of-life interventions rather than solely curative oncologic protocols.

Patients who experience only partial symptom relief after their initial course of low-dose radiation therapy (LDRT) are eligible for a second treatment cycle, typically initiated approximately 90 days after completion of the first. This interval allows sufficient time for the full anti-inflammatory and analgesic effects of radiation to manifest. All patients are scheduled for a 90-day follow-up visit to assess their degree of pain reduction, functional improvement, and overall satisfaction. Those demonstrating meaningful but incomplete improvement may proceed with a second round of therapy following multidisciplinary review. To date, no patients at our facility have required a third course of LDRT, suggesting that two cycles are generally adequate for durable relief in responsive cases. Conversely, patients who report no measurable improvement after the first course are classified as non-responders, and repeat irradiation is typically not recommended, as further benefit is unlikely.

This initiative also highlights the integral role of podiatry in multidisciplinary medicine. Podiatrists are uniquely positioned at the intersection of orthopedics, wound care, and rehabilitative medicine, often serving as the first specialists to identify chronic degenerative or inflammatory foot conditions that are refractory to standard therapies. The collaboration between podiatry and radiation oncology in delivering LDRT exemplifies a modern, team-based approach to musculoskeletal care. By partnering closely with radiation oncologists, podiatrists can extend the therapeutic spectrum available to patients, offering an evidence-based and minimally invasive option for pain relief and functional restoration. Precise localization and radiation field design are crucial when targeting small-volume structures like the plantar fascia or joints of the foot. This cooperative model not only optimizes outcomes but also reinforces the value of integrated specialty medicine in addressing complex lower extremity disorders.

Low-dose radiation therapy (LDRT) represents an exciting re-emergence of a time-tested modality now being applied to chronic, debilitating foot and ankle disorders such as osteoarthritis and plantar fasciitis. The remarkable outcomes observed in this series demonstrate that LDRT can provide meaningful, durable pain relief and functional improvement in patients who have exhausted conventional therapies. Beyond its therapeutic impact, this work underscores the expanding role of podiatrists as active collaborators in multidisciplinary care, bridging orthopedic, radiologic, and rehabilitative disciplines to deliver innovative, patient-centered solutions. As evidence continues to accumulate, LDRT may become an increasingly important adjunct in the podiatric armamentarium for managing recalcitrant degenerative and inflammatory conditions of the foot, reaffirming the specialty's commitment to advancing both function and quality of life through interdisciplinary innovation.

Conflict of Interest Statement

The authors of this article declare no conflict of interest. The companies involved had no role in the design of the study; in the collection, analyses, or interpretation of date; in the writing of the manuscript, or in the decision to publish the results.

References – Scan QR Code