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Radiation-Induced Digital Neuropathy in an Interventional Physiatrist: Rapid and Durable Relief after Targeted Digital Nerve Block: Case Report

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Background: Hands are frequently closest to the primary beam during fluoroscopy and can sustain cumulative exposure. Case reports of focal digital neuropathy in proceduralists are rare; imaging may be nondiagnostic, and treatment pathways unclear.

Case Report: A 36-year-old interventional physiatrist developed 9 months of cyclical, severe allodynia localized to the radial half of the right index distal phalanx. Infectious/inflammatory treatments and hand therapy were ineffective. MRI was nonspecific; ultrasound showed focal hyperemia. Given typical hand positioning during procedures, radiation-induced digital neuropathy was suspected. A targeted radial digital nerve block at the distal interphalangeal level achieved near-complete pain relief by day 10 with durable benefit at 12 months.

Conclusion: In clinicians with focal fingertip allodynia and nondiagnostic imaging, consider radiation-induced digital neuropathy. When conservative care fails, a targeted digital nerve block may provide rapid, durable relief and underscores best-practice radiation safety.

Key words: Digital neuropathy; ionizing radiation; fluoroscopy; occupational exposure; interventional physiatry; digital nerve block; allodynia; hand pain; case report

BACKGROUND

Occupational ionizing radiation remains an essential but mitigable hazard in image-guided spine and pain procedures. Hands are uniquely vulnerable: they may approach the primary beam while manipulating needles or confirming targets. Prospective operator-dosimetry confirms meaningful cumulative dose to the dominant hand during fluoroscopically guided procedures; in one prospective series, the authors note that "the hands of spinal surgeons are placed close to the field of radiation," (1) indicating the presence of occupational risk of numerous specialties.

Multiple consensus resources emphasize behavior-based prevention: "Never place your hands in the x-ray beam" (2), "Keep hands out of the beam" (3), and "Keep hands out of the primary beam unless unavoidable for clinical reasons" (4,5). Despite this, real-world practice is imperfect and fingers are sometimes "accidentally caught in the beam" (6).

Radiation-induced peripheral neuropathy (RIPN) is classically described after therapeutic radiotherapy, often with delayed onset and progression; a seminal review characterizes RIPN as "progressive and usually irreversible" (7). While the setting here is occupational rather than therapeutic radiation, the pathobiology (direct axonal injury, ischemia, and fibrosis) and symp-

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tom complex (neuropathic pain and sensory change) are a useful framework when evaluating focal digital symptoms in proceduralists.

We describe a focal, hemipulp digital neuropathy in an interventional physiatrist with repetitive fluoroscopic exposure and durable response to a targeted digital nerve block. This report follows PMCR structure and CARE elements.

CASE PRESENTATION

A 36-year-old right-handed man interventional physiatrist presented with a 9-month history of severe, cyclical neuropathic pain localized to the radial half of the right index distal phalanx, maximal at the nail bed (Fig. 1). Pain quality was a deep ache with marked brush allodynia. Flares recurred every 3–4 weeks, with partial quiescence between episodes. There was no antecedent trauma.

Prior empiric treatments (soaks; topical and oral antibiotics/antifungals; topical diclofenac and lidocaine) provided no benefit. Examination demonstrated point allodynia of the radial hemipulp without swelling or mass. Magnetic resonance imaging (MRI) revealed only mild, nonspecific enhancement of the distal phalanx; musculoskeletal ultrasound showed focal hyperemia limited to the symptomatic area soft tissue without observable change to the periosteum. Months of hand therapy (strengthening, laser, mirror therapy, contrast baths) did not improve symptoms. During therapy he developed transient thenar/thumb paresthesias that resolved after median nerve hydrodissection; the index-fingertip pain persisted, suggesting a separate etiology.

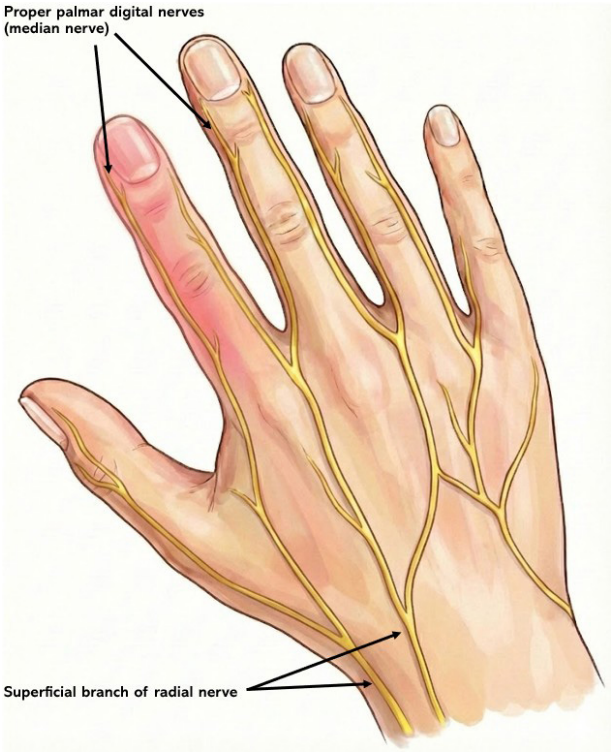

Fig. 1. Illustrated demonstration of pain symptoms corresponding with underlying anatomy and proximity to proper palmar digital nerves as well as superficial branches of radial nerves.

Given frequent hand positioning during fluoroscopy (index finger used to confirm needle trajectory in lateral views), repeated micro-exposures were suspected to have injured the radial digital nerve branch supplying the symptomatic hemipulp.

Differential Diagnosis

Differential considerations included paronychia (absent exam findings; treatment failure), glomus tumor (no mass on MRI), complex regional pain syndrome (Budapest criteria unmet), median neuropathy (separate, resolved symptoms), and occult fracture (no trauma; imaging negative). The precise hemipulp distribution and occupational pattern favored a localized radiation-related digital neuropathy.

Intervention

Approximately 9 months after onset, a radial digital nerve block was performed at the distal interphalangeal (DIP) level using standard sterile technique under ultrasound guidance. A high frequency linear hockey stick transducer was positioned in the transverse plane along the volar (palmar) surface of the proximal phalanx, and a 27-gauge needle was advanced in plane with the probe to the perineural region of the radial digital nerve supplying the symptomatic hemipulp. A total of 1.0 mL injectate containing 1.5 mg betamethasone plus 0.5 mL lidocaine was administered (Fig. 2).

Outcome

By day 10 post-block, the patient reported near-complete pain relief. Flares ceased, function normalized, and he resumed full procedural duties. At 12-month follow-up, relief remained durable without repeat injection. No complications occurred.

Literature Context

Operator hand dose varies widely with C-arm geom-

etry, beam orientation, patient habitus, and technique. Dose-sparing practices, such as tight collimation, pulsed fluoroscopy at the lowest acceptable frame rate, maximizing distance from the tube, and using ceiling-suspended shields, reduce scatter, and as interventional cardiology consensus stresses, less dose to the patient generally means less scatter to staff (8). Randomized and observational data together support keeping hands out of the field and substituting instruments (forceps/needle-holders) for fingers whenever possible (9).

DISCUSSION

Why suspect radiation-induced digital neuropathy? The clinical picture consisted primarily of focal hemipulp allodynia, nondiagnostic imaging, failed infectious/inflammatory therapies, and occupational exposure. This vignette supports a peripheral generator. Operator-dosimetry studies show that surgeon and proceduralist hands receive substantial dose during common procedures (1,9,10).

Occupational safety statements outline why meticulous technique matters. The IAEA advises: "Keep hands out of the primary beam unless unavoidable for clinical reasons" (4,5); the NCI notes, "Keep hands out of the beam" (3). Interventional safety reviews reiterate: "Never place your hands in the X-ray beam" (2). Collectively, these underscore that avoiding the primary beam trumps any attenuation glove once the hand is inside the beam. Observational literature recognizes that, despite awareness, fingers are sometimes "accidentally caught in the beam" (6) (Fig. 3). OSHA guidance is explicit: "Wear finger ring dosimeters on the hand which is closest to the radiation source" (11).

Pathobiology parallels radiotherapy-related neuropathy: direct axonal injury, ischemic microvascular damage, and fibrosis that can entrap small digital branches. Authoritative reviews describe radiation-induced neuropathy as "progressive and usually irreversible" (7), and case literature describes it as "often progressive, (and) unresponsive to conservative treatment" (12). Our patient's occupational exposure was far lower than therapeutic radiotherapy, but the focal neuropathic pain phenotype and exam are concordant.

Therapeutic RIPN most often follows high-dose, fractionated radiotherapy delivered to a defined anatomic field, where major nerve trunks or plexuses are exposed within (or adjacent to) the treatment volume. In that setting, late microvascular injury and progressive fibrosis help explain the classic delayed onset and frequently progressive, treatment-refractory course described in the RIPN literature. By contrast, occupational fluoroscopy-related exposure is typically low-dose per event but repetitive, and risk concentrates in tissues that intermittently experience greatest primary-beam proximity or scatter, most notably the hands and fingers, favoring a focal, branch-level phenotype (for example, isolated digital allodynia) with

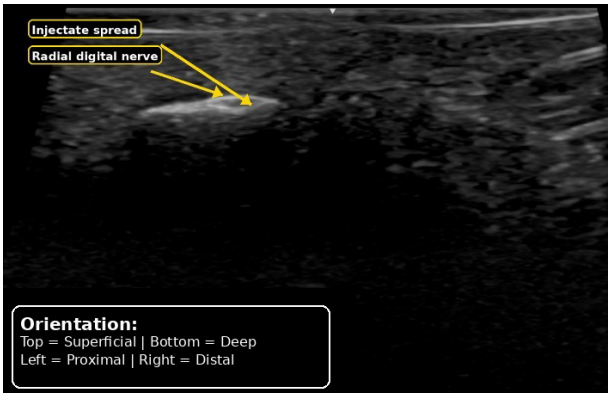

Fig. 2. Ultrasound guided radial digital nerve block at the DIP level (transverse volar approach). Post injection image demonstrating spread of the 1.0 mL injectate surrounding the targeted perineural region.

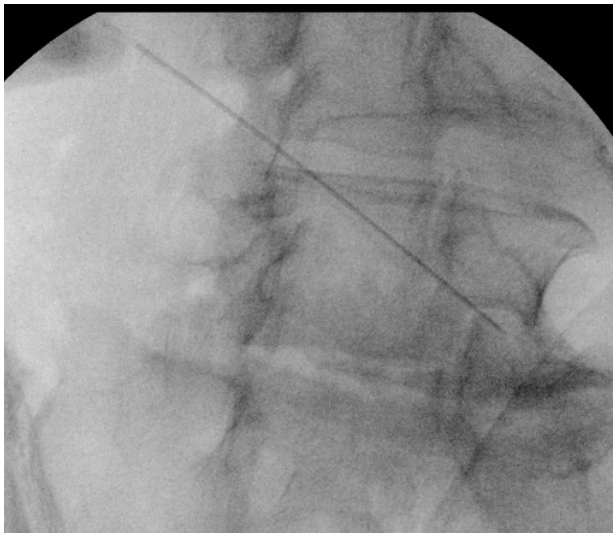

Fig. 3. Example fluoroscopic lateral view during image-guided needle positioning demonstrating inadvertent proximity of the operator's hand to the imaging field. The thumb and index fingers are visible at the image margins (top left), illustrating potential for intermittent primary beam inclusion during trajectory confirmation.

Fig. 4. Proceduralist hand position while using a 22-gauge 3.5 inch spinal needle to localize an injection target under fluoroscopy. The image demonstrates how finger placement used to confirm needle trajectory can approach the field of view during lateral imaging.

often nondiagnostic imaging. This distinction matters clinically because, while mechanisms may overlap, the occupational context is more strongly shaped by modifiable procedural behaviors and monitoring (for example, ring dosimetry), which are repeatedly emphasized in safety guidance.

Why did a digital nerve block work? Peripheral nerve blockade can interrupt ectopic firing, suppress neurogenic inflammation, and, in some cases, "reset" peripheral nociceptor activity sufficiently to produce durable symptomatic benefit. Although formal trials in occupational radiation-related digital neuropathy are lacking, a targeted block matches the symptom map and provides both diagnostic (peripheral generator confirmation) and therapeutic value. Rapid, sustained relief after DIP-level radial digital nerve block supports a localized digital neuropathy rather than a proximal or systemic process.

Prevention: practical steps for interventionalists. Multiple sources agree on foundational behaviors: One, avoid the beam. "Never place your hands in the X-ray beam" (2), "Keep hands out of the beam" (3), and "Keep hands out of the primary beam unless unavoidable" (4,5); Two, recognize risk. The "hands of the working provider are subject to high amounts of scatter radiation as well as the possible risk of entering the field of the primary beam" (10); Three, do not over-rely on gloves. Medically approved, sterile radiation attenuating gloves are prohibitively expensive. Furthermore, EuroSafe cautions, "In general the operator's hands should never be exposed to primary radiation beam"(13), regardless of utilization of such measures; Four, use tools, not fingers (Fig. 3). Randomized study data show that using a radiation-reduction glove or forceps "greatly decreased the radiation exposure" during selective nerve root block (9). Additionally, some consideration should be given to the option of utilizing a longer needle in order to further distance the proceduralist's hands from the field of exposure; and five, adopt dose-sparing technique (collimation, pulsed fluoro, optimizing C-arm geometry) per interventional best-practice statements (2,8).

Imaging considerations

In small-fiber or branch-level digital neuropathies, anatomic MRI is often normal. In the occupational-exposure context, normal MRI does not exclude a peripheral neuropathy; here, the focused symptom map and exposure pattern carried more weight than equivocal imaging.

Limitations

This is a single case without fingertip dosimetry, and causality cannot be proven. Nevertheless, precise hemipulp distribution, failure of infectious/inflammatory treatments, normal/indeterminate imaging, occupational exposure pattern with plausible primary-beam proximity, and durable relief after a targeted digital block together support a localized radiation-related digital neuropathy.

CONCLUSION

In proceduralists with focal fingertip allodynia and nondiagnostic imaging, radiation-induced digital neuropathy should be considered. When conservative measures fail, a digital nerve block may provide rapid, durable relief. Prevention remains paramount: keep hands out of the beam, use instruments rather than fingers to confirm targets, employ pulsed/low-dose and collimation strategies, and wear ring dosimeters on the at-risk hand.

Author Contributions

Jonathan Kallini: Conceptualization; Investigation; Writing - original draft; Illustration. Drew Barron: Data curation; Literature search; Writing - review & editing. Nesbit Sloan: Methodology; Writing - review & editing. Min Yoo, MD: Supervision; Clinical procedure;

Resources; Writing - critical revision. Bryan Ganter, MD: Methodology; Clinical procedure; Resources; Writing - critical revision. Gregory Umphrey, MD: Methodology; Clinical procedure; Resources; Writing - critical revision. All authors approved the final manuscript and agree to be accountable for all aspects of the work.

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