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CT-Based Planning of Individualized Electron Therapy for Dupuytren's and Ledderhose Disease: Optimizing Electron Energy, Bolus Thickness, and Prescription Depth

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Abstract

Purpose: The purpose of this study is to document the role of CT imaging during treatment planning for palmar (Dupuytren's disease) and plantar (Morbus Ledderhose) fibromatoses using enface electron fields. European studies have reported excellent outcomes with radiotherapy in early-stage disease, typically using kilovoltage (kV) photon beams. More recently, megavoltage (MV) electrons have been employed more frequently, sometimes using "standard" prescriptions. Given the substantial variability in target depth between patients, CT-based planning has the potential to optimize planning parameters. This study analyzes how CT simulation can guide personalized radiotherapy for palmar and plantar fibromatoses.

Methods: A review was performed of 196 extremity treatments (153 hands, 43 feet) for Dupuytren's and Ledderhose disease across 82 patients enrolled in a departmental registry who underwent radiotherapy between 2008 and 2022. Planning CT scans were used for dose calculations of all treatments. Planning parameters including electron energy, bolus thickness, and prescription depth were extracted from the departmental database and analyzed by treatment site and sex.

Results: Overall, 70.9% of treatments used 6 MeV electrons, while 29.1% required 9 or 12 MeV. Among hand treatments, 81.7% used 6 MeV, with female patients more frequently treated with 6 MeV (95.2%) compared to males (65.7%) who often required higher energies of 9 or 12 MeV. In contrast, plantar treatments demonstrated greater variability, requiring >6 MeV in 67.4% of cases overall, with male patients more often requiring >6 MeV (84.2% male vs 54.2% female). Additionally, only 26.5% of treatments incorporated a 5 mm bolus, with comparable usage between hands (26.8%) and feet (25.6%), while the remaining 73.5% utilized thicker boluses (6–15 mm). Finally, 83.7% of prescriptions were delivered to the 90% isodose line. Hand treatments demonstrated overall consistent prescription depth, with 86.9% prescribed to 90%, 1.3% to 85%, 4.6% to 95%, and 3.9% to 100% isodose line (no data in 3.1%). Plantar treatments showed greater variability, with 72.1% prescribed to 90% isodose line and 7% each to 85% and 95% isodose lines (no data in 13.9%). Only 19.9% of treatments used 6 MeV and 5 mm bolus to 90% depth, while 34.2% utilized 6 MeV and 10 mm bolus to 90% depth, indicating that "standard" prescriptions were applied in little more than half of all treatments.

Conclusion: Substantial anatomical variation in target depth exists between hands and feet as well as between sexes, supporting the need for individualized prescriptions in enface electron treatments of palmar and plantar radiotherapy. Image-based assessment of target depth—such as CT imaging, which is widely available in radiation therapy departments—enables patient-specific dose planning that optimizes target coverage, dose uniformity, and sparing of uninvolved tissue, demonstrating its potential to enhance treatment quality and outcomes in radiotherapy for Dupuytren's and Ledderhose disease.