SIMULATION OF SN-117M RADIOSYNOVIORTHESIS INCLUDING PHAGOCYTOTIC MIGRATION WITHIN THE JOINT

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Introduction: Radiosynoviorthesis (a.k.a. radiosynovectomy) treats arthritis by the intra-articular injection of a radioactive colloid. The radionuclides that are most often used are Y-90 for large joints, Re-186 for medium-sized joints and Er-169 for small joints, along with P-32 for treating hemophilic arthropathy. An ongoing trial of a novel colloid of Sn-117m, which emits therapeutic conversion electrons (~140 keV, 112%; range ~300 um), is producing very encouraging results in the treatment of arthritic canine elbow joints. These are comparable in size to some human joints. The 14-day physical half-life of Sn-117m allows time for phagocytosis and migration of the radioactive particles deeper into the tissue. It is thus conceivable that Sn-117m could treat larger joints with thicker synovia while still sparing the cartilage and bone. This study simulated moving distributions of the radionuclides in order to estimate the radiation absorbed dose in the structures of a treated joint.

Methods: A simple model of the layers of a moderately arthritic joint by Johnson, et al., was simulated in the GATE Monte Carlo software for each of the five radionuclides above. Initially, a quasi-dynamic model was used in which the activity distribution changed once a week among the 0.44 mm thick capsule, the 0.3 mm thick lining, and the first four 0.5 mm thick subintimal layers. The activity was uniformly spread across the capsule and lining during the first week. In subsequent weekly periods, half of the activity remained in the lining while the other half migrated progressively deeper into the subintimal layers until one-eighth was distributed in each of the four. The motion of the activity was assumed to cease in this final distribution. The administered activities of the various radionuclides were chosen to equalize the dose at the interface between the capsule and the lining. A more refined model in which the radioactivity moves continuously is being developed.

Results: The administered activities relative to 1 MBq/cm^2 of Sn-117m were Y-90: 2.65, P-32: 0.463, Re-186: 2.47, and Er-169: 2.20 MBq/cm^2. The quasi-dynamic model produced dose distributions in which Y-90 and P-32 had very broad coverage, both of the bone and cartilage and of the deeper subintimal layers. The doses from Sn-117m, Er-169 and Re-186 were very similar in the subintimal layers whereas Re-186 delivered an appreciable dose to the cartilage while Sn-117m and Er-169 spared it almost completely. Sn-117m and Er-169 delivered a similar dose to the lining.

Conclusion: Sn-117m, Er-169 and P-32 all have half-lives that are long enough that the migration of the phagocytosed particles through the synovial layers has a significant effect on the intimal dose profiles. When this migration is modeled, the resulting dose distribution of Sn-117m spares the cartilage and bone as well as Er-169 does while delivering a dose to the intimal layers that is equivalent to that of Re-186. Thus, Sn-117m shows promise for the treatment of medium-sized joints as well as of smaller joints.

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Keywords: Sn-117m, radiosynoviorthesis, synovium, dosimetry, Monte Carlo simulation