Supplement 1

Our choice of the dose-dependent correction term for RBE_T in Equation 3 might be better explained by including this brief derivation. Generally, RBE is given as the ratio of fraction doses (*d*) for a reference radiation (e.g., by 250 kVp x-rays) and a test radiation (here ion radiation) under the condition that the two doses induce the same biological effect to cells or tissues.

$$\mathrm{RBE} = \frac{d_x}{d_i} \tag{S1.1}$$

where *x* indicates x rays and *i* indicates ions (i.e., protons or carbon-ions). As long as the linear-quadratic model holds, and, in particular, fraction doses are low enough to discard the high-dose transition to a linear part, the effect equality requires

$$\alpha_i d_i + \beta_i d_i^2 = \alpha_x d_x + \beta_x d_x^2 \tag{S1.2}$$

Equation A.2 can be solved for d_x and plugged into the numerator of the RBE definition (A.1), resulting in

$$\mathrm{RBE} = \frac{\sqrt{\alpha_x^2 + 4\beta_x(\alpha_i d_i + \beta_i d_i^2)} - \alpha_x}{2\beta_x d_i} \tag{S1.3}$$

which can be used to predict RBE as a function of d_i. However, α/β values must be known or estimated for both x-ray and ion irradiation for the tissues of interest.