abstract In dense stellar clusters, binary-single and binary-binary encounters can ultimately lead to collisions involving two or more stars during a resonant interaction. A comprehensive survey of multi-star collisions would need to explore an enormous amount of parameter space, but here we focus on a number of representative cases involving low-mass (0.4, 0.6, and 0.8 $M_\odot$) main-sequence stars. Using both Smoothed Particle Hydrodynamics (SPH) calculations and a much faster fluid sorting software package (MMAS), we study scenarios in which a newly formed product from an initial collision collides with a third parent star. By varying the order in which the parent stars collide, as well as the orbital parameters of the collision trajectories, we investigate how factors such as shock heating affect the chemical composition and structure profiles of the collision product. Our simulations and models indicate that the distribution of most chemical elements within the final product is not significantly affected by the order in which the stars collide, the direction of approach of the third parent star, or the periastron separations of the collisions. Although the exact surface abundances of beryllium and lithium in the product do depend on the details of the dynamics, these elements are always severely depleted due to mass loss during the collisions. We find that the sizes of the products, and hence their collisional cross sections for subsequent encounters, can be sensitive to the order and geometry of the collisions. For the cases that we consider, the radius of the product formed in the first (single-single star) collision ranges anywhere from roughly 2 to 30 times the sum of the radii of its parent stars. The size of the final product formed in our triple-star collisions is more difficult to determine, but it can easily be as large or larger than a typical red giant. Although the vast majority of the volume in such a product contains diffuse gas that could be readily stripped in subsequent interactions, we nevertheless expect the collisional cross section of a newly formed product to be greatly enhanced over that of a thermally relaxed star of the same mass. Our results also help establish that the algorithms of MMAS can quickly reproduce the important features of our SPH models for these collisions, even when one of the parent stars is itself a former product.