Purpose: Significant efforts have been made through federal, industrial and institutional funding to develop cost-effective alternatives to conventional accelerator-based particle therapy. This presentation reviews the development of laser-accelerated particle beams as an alternative to conventional accelerators for particle therapy.

Method and Materials: Many institutions and research groups have focused on their research on the applications of laser-accelerated proton and ion beams for medical applications, in particular for radiotherapy treatments. These include extensive investigations of optimal laser parameters and target designs to achieve therapeutic particle energies, compact particle selection and beam collimation designs for novel compact particle therapy systems, dose calculation and treatment optimization for laser-accelerated proton beams, and system and shielding designs for clinical prototype machines. Fox Chase Cancer Center has established a laser-ion acceleration facility that consists of a commercial 150 TW laser, custom-made laser-pulse compression and target chambers, particle selection and beam collimating devices, dosimetry monitoring systems and shielding constructions. Initial laser-proton acceleration experiments were performed with thin aluminum and plastic foils as target materials. Particle-in-cell (PIC) simulations were carried out to investigate the optimal laser parameters and target configurations to facilitate laser-proton acceleration and dosimetric studies.

Results: The maximum proton energy achieved by laser acceleration was 58 MeV. Our initial testing with a 10^{18} W/cm^2 laser intensity (at 20 TW) produced up to 4 MeV protons with a broad energy spectrum, which confirmed the scalability of laser intensity and maximum proton energy. A compact shielding designed was investigated using Monte Carlo simulations that allows for the installation of the particle therapy head on a small rotating gantry.

Conclusion: Laser-accelerated proton and ion beams have a great potential to replace conventional radiotherapy systems due to its compact design and cost-effectiveness. Many technical and engineering issues must be solved before a clinical prototype can be built for radiotherapy applications.