A fast-readout dosimetry system based on fibre-coupled organic scintillators has been developed for the purpose of conducting point measurements of absorbed dose in radiotherapy beams involving high spatial and temporal dose gradients. The system measures the dose for each linac radiation pulse with millimetre spatial resolution. To demonstrate the applicability of the system in complex radiotherapy fields, output factors and per cent depth dose measurements were performed in solid water for a 6 MV photon beam and compared with Monte Carlo simulated doses for square fields down to 0.6 cm × 0.6 cm size. No significant differences between measurements and simulations were observed. The temporal resolution of the system was demonstrated by measuring dose per pulse, beam start-up transients and the quality factor for 6 MV. The precision of dose per pulse measurements was within 2.7% (1 SD) for a 10 cm × 10 cm field at 10 cm depth. The dose per pulse behaviour compared well with linac target current measurements and accumulated dose measurements, and the system was able to resolve transient dose delivery differences between two Varian linac builds. The system therefore shows promise for reference dosimetry and quality assurance of complex radiotherapy treatments.