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An acoustic technique for mapping and sizing particles following needle-free transdermal drug and vaccine delivery

Jamie Condliffe, Heiko Schiffter and Constantin Coussios
University of Oxford, Medical Engineering Unit, 43 Banbury Road, OX2 6PE Oxford, UK

Needle-free ballistic particle injection enables painless transdermal delivery of pharmaceuticals. To improve the efficacy of this technique, a non-invasive method of assessing particle penetration depth, distribution and changes in particle size following injection is required. Polydisperse distributions of polystyrene particles, mean diameter 25μm, and insulin particles, mean diameter 44μm, were injected into both tissue-mimicking phantoms and porcine skin, which they penetrate to a mean depth of 300μm. Following injection, the surface of the targets was scanned using a 50MHz focused ultrasound transducer driven in pulse-echo mode. The received waveforms were post-processed to estimate particle penetration depth and distribution in the plane perpendicular to injection. The targets were then sectioned and optical microscopy was used to validate the acoustic results. Furthermore, computational implementation of an exact solution for sound scattering by an elastic sphere allows prediction of the frequency response of the insonified particles. Direct comparison of the theoretical model with the frequency content of experimental data is shown to provide an accurate means of estimating particle size, and is being extended to correlating particle size with penetration depth. The acoustic technique shows great promise as a non-invasive means of mapping, sizing and assessing stability of drug particles following needle-free injection.