The Role of Impulse, Tissue Stretching, and Tip Geometry for Tissue Penetration of Polymer Needles

Polymer needles for medical injections offer a range of opportunities like compatibility with magnetic resonance scanning and simultaneous delivery of more than one drug. However, the lower stiffness property of polymers compared to steel is a challenge for penetration. This paper explores strategies for higher penetration success, which include impulse insertion, tissue stretching, and different tip geometries. The strategies are experimentally examined using three layers of nitrile rubber gloves and sticking glue to create an artificial skin model. It is demonstrated that polymer needles have higher penetration rates when the strategies are applied. Penetration rates were only 10–20% when using slow speed insertion (0.2 mm/s) but 100% penetration rates was achieved using impulse insertion. Penetration forces are similar for slow insertion speed and high speed (impulse insertion) and for needles made out of different material (polymer or steel). Conical and pyramidal tips were studied for polymer needles and a commercial bevel steel needle tip. The result was lower penetration forces and 100% penetration success was possible using the pyramidal polymer needles. For the model in study was observed a similar behavior (penetration force and rate of penetration success) for steel and polymer pyramidal needles. An analysis of variance statistical analysis show significance when using springs and strain, as well for the combination of both.

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Contributors: Silva, P. I. D. M. E., Drakidis, A., Gomes, S., Lenau, T. A.
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