

**Fig. S1** (A-B) the CONSORT flow chart of two pilot randomized clinical trials.



**Fig. S2** (A) Example of NLFJI using 90 psi and 1mL, the penetration distance is measured frame by frame from the high-speed camera video, the velocity and acceleration versus time were calculated accordingly. The velocity change was not linear. (B) Model fitting based on a previous study (Baxter and Mitragotri, 2005) using the example of 90 psi and 1 mL, another model fitting is shown in table S1.



**Fig. S3** (A-D) Examples of force-time history for NFLJI and needle injections. The a-e in Fig. A and B are matched with a-e in Fig. 4 E and F. (E-F). Examples of laceration caused by NFLJI for mental nerve block and a few cases caused by perpendicular infiltration anesthesia.

A picture containing diagram

Description automatically generated

**Fig. S4 A-E** the relationship between discharge coefficient and Reynolds numbers based on different piston injection rate. **F** Piston resistance force at different piston injection rates.

**A screenshot of a computer

Description automatically generated with medium confidence**

**Fig. S5** Methodologyfor collecting piston displacement and piston resistant force, these data were used to calculate the discharge coefficient and Reynold number.

**Table S1** Continuation of Fig. 4, showing examples of estimation for jet impinge pressure (first raw) and jet maximum penetration pressure (second raw).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 413 kPa | Time (s) | Force (N) | Depth (mm) | Width (mm) | Pressure (kPa) |
| Fig 4 E | 0 | 0.113 | 0 | 0.4 | **896.8** |
| a | 0.0001 | 0.113 | 6.16 | 1.72 | **48.6** |
| b | 0.185 | 0.115 | 25.62 | 5.2 | 22. 2 |
| c | 0.37 | 0.123 | 31.22 | 6.5 | 18.9 |
| d | 0.555 | 0.128 | 35.99 | 10.06 | 12.7 |
| e | 0.74 | 0.134 | 40.04 | 11.89 | 11.3 |
| 620 kPa | Time (s) | Force (N) | Depth (mm) | Width (mm) | Pressure (kPa) |
| Fig 4 F | 0 | 0.151 | 0 | 0.4 | **1198** |
| a | 0.0001 | 0.151 | 11.18 | 1.85 | **56.3** |
| b | 0.141 | 0.162 | 29.40 | 5.33 | 30.4 |
| c | 0.282 | 0.161 | 35.39 | 4.31 | 37.4 |
| d | 0.423 | 0.166 | 60.10 | 4.46 | 37.2 |
| e | 0.564 | 0.182 | 67.15 | 4.43 | 41.1 |

**Table S2** The model fitting based on previous study (Baxter and Mitragotri, 2005)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Pressure (psi) | Volume (mL) | m | b | Estimated depth(mm) | Actual mean depth(mm) | R2 |
| 60 | 1 | -0.0003 | 0.0947 | 84.6 | 48.3 | 7.84% |
| 90 | 1 | -0.0002 | 0.0926 | 129.2 | 51.8 | 13.69% |
| 120 | 1 | -0.0004 | 0.1753 | 38.9 | 72.6 | 20.53% |
| RSMD = 54.2 mm | | | | | | |

**Table S3** The discharge coefficient of jet orifice based on different piston injection rates.

|  |  |
| --- | --- |
| *v*\_ piston (mm/s) | Cd, mean (SD) |
| 10 | 0.69 (0.038) |
| 20 | 0.84 (0.038) |
| 30 | 0.90 (0.032) |
| 40 | 0.91 (0.029) |
| 50 | 0.90 (0.027) |

The discharge coefficient is calculated as follows:

We first collected the piston resisting force and displacement/time history at different piston injection rates (Fig S5). This data allowed us to calculate the actual and theoretical flow rate.

The actual jet volume flow rate could be calculated from piston injection rate and piston cross-sectional area.

Eq (s1)

Where is the dynamic velocity during injection, is the area of piston (d= 7 mm).

The theoretical maximum flow rate is calculated as follows:

Eq (s2)

Eq (s3)

where F is the dynamic force of the piston during the injection. The relationship between the stable piston resistance force and the piston injection rate is shown in Fig S4 F. is the area of the piston, is the area of the nozzle orifice, is atmosphere pressure,is the density of water.

The discharge coefficient is the actual flow rate divided by the theoretical flow rate.

Eq (s4)

In addition, the Reynolds number of fluids was calculated based on the calculated Bernoulli velocity of the fluid.

Eq (s5)

Where is the diameter of nozzle orifice, is the viscosity of water,is the density of water, is atmosphere pressure, is obtained from Eq (s2).

The relationships between Reynolds number and the discharge coefficient at different piston injection rates were presented in Fig S4 A-E.