Supplementary Information (SI) for Lab on a Chip.

Supplementary File

Microfluidic Profiling of Suspension Cell–Metal Adhesion at Single-Cell Resolution Under Flow

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Figure S1

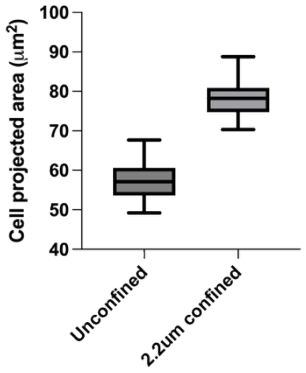

Figure S1. RBCs were observed to exhibit an increased projected area under confined channel conditions compared to unconfined conditions, indicating partial vertical deformation under the selected channel height.

Figure S2

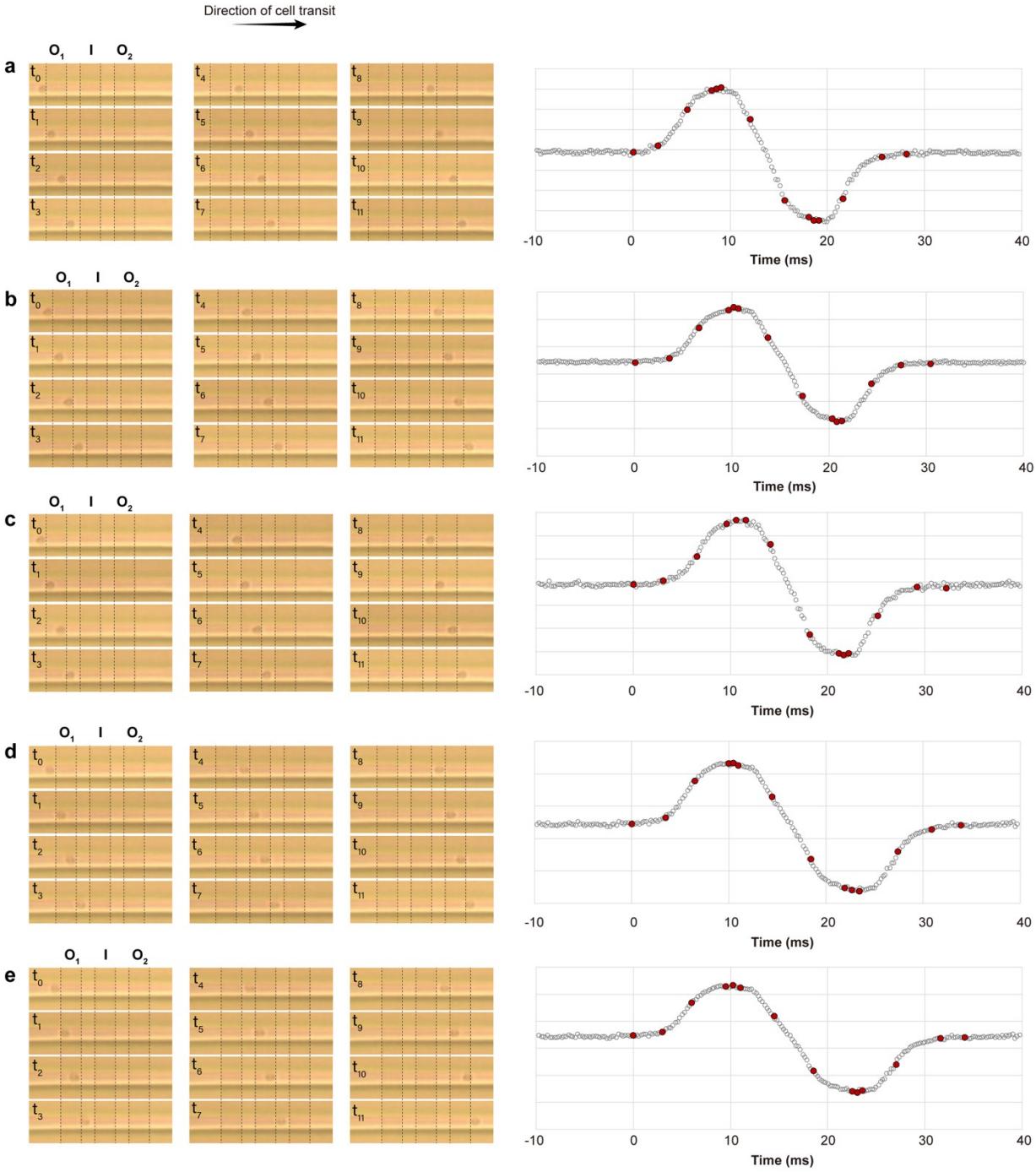

Figure S2. **Examples of electrical signal waveforms obtained from 5 individual RBCs.** (a-e) To clearly visualize cell movement, a microfluidic channel with indium tin oxide (ITO) electrodes was fabricated, allowing simultaneous observation of RBC transit across three electrodes (O_1: output$_1$, I: input, O_2: output$_2$) and the corresponding electrical signals. Twelve representative time points were identified from the recorded images and mapped onto the signal traces: t_o

(initial contact with O_1), t_1 (fully on O_1), t_2 (just before exiting O_1), t_3 (just after exiting O_1), t_4 (before contacting I), t_5 (fully on I), t_6 (just before exiting I), t_7 (just after exiting I), t_8 (initial contact with O_2), t_9 (fully on O_2), t_{10} (just before exiting O_2), and t_{11} (after completely exiting O_2).When a cell transits across the O_1, the measured voltage increases rapidly due to the change in the relative position between the cell and the input electrode. As the cell moves away from O_1 toward the I electrode, the rate of voltage increase gradually decreases. When the cell begins to partially overlap with the I electrode, the voltage starts to decrease gradually, and when the center of the cell aligns with the center of the I electrode, the signal returns to the baseline level. As the cell continues to move into the inter-electrode region, the voltage decreases further and reaches a minimum. When the cell approaches the O_2 electrode, the voltage increases again, and once the cell has completely passed through the electrode region, the signal returns to the baseline. The measured morphological features and corresponding electrical signal values for each cell are summarized in **Table S1**.

Figure S3

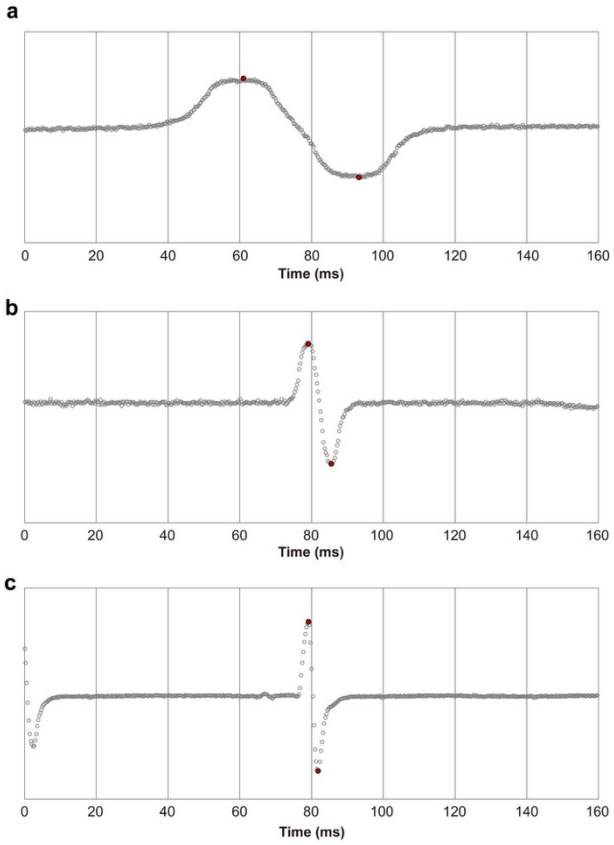

Figure S3. Representative electrical signal waveforms obtained at different RBC transit velocities. Representative signal waveforms obtained at different cell transit velocities: (a) 1 mm/s, (b) 4.5 mm/s, and (c) 11 mm/s. The maximum and minimum peaks used for transit time analysis are indicated by red circles.

Figure S4

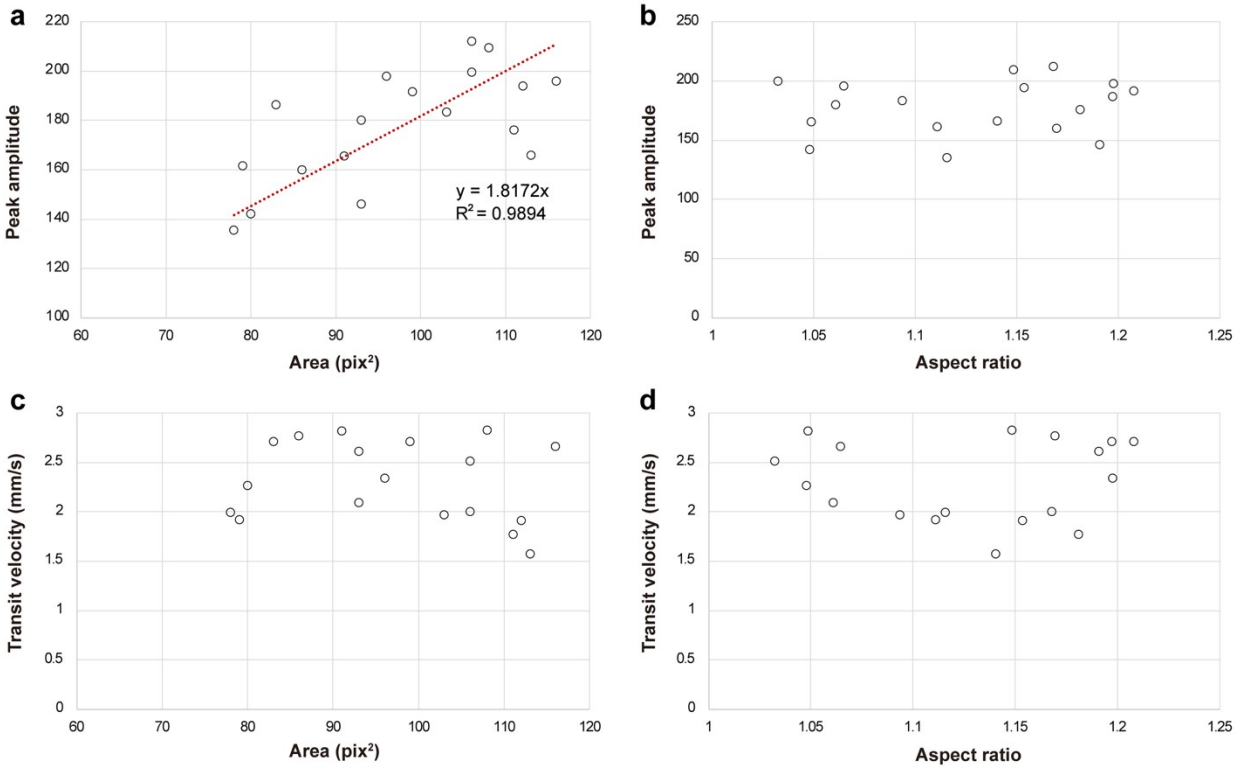

Figure S4. Relationship between cell morphological parameters and measured electrical signals. Cell morphology was quantified from microscopic images using the projected area and aspect ratio (defined as the ratio of the major to minor axis of an ellipse fitted to the cell shape). The electrical measurements included peak amplitude and transit velocity. (a) Relationship between projected cell area and peak amplitude, showing a strong positive correlation. (b) Relationship between aspect ratio and peak amplitude, showing no clear correlation. (c) Relationship between projected cell area and transit velocity, showing no significant correlation. (d) Relationship between aspect ratio and transit velocity, also showing no significant correlation. (N = 2, total number of cells = 18).

Figure S5

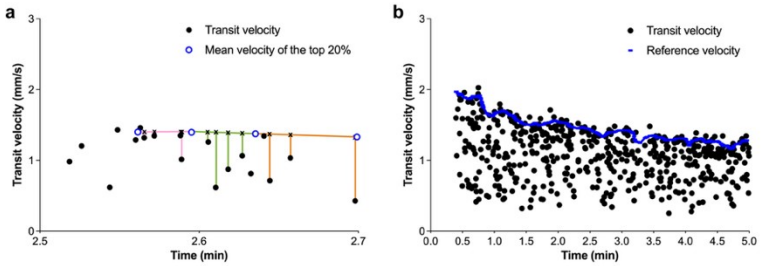

Figure S5. Calculation of reference velocities to normalize transit velocity. (a) Schematic illustration of reference velocity estimation within the 2.5-2.7 min interval shown in **Figure 5b**. For each cell, the two nearest reference velocities (mean of the top 20%) were connected by linear interpolation, and the expected reference velocity at the cell's transit time was estimated accordingly (black x). (b) Calculated reference velocities (blue line) overlaid with individual cell transit velocities (black circles).

Figure S6

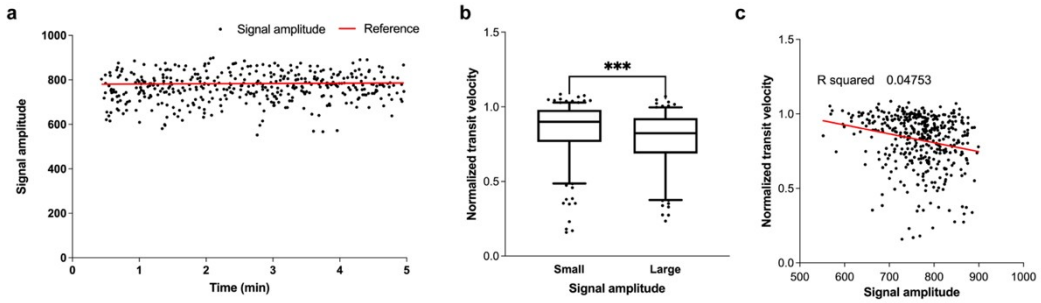

Figure S6. Effect of cell size-approximated by impedance signal amplitude-on normalized transit velocity. (a) Representative raw impedance signals of individual RBCs showing a distribution of signal amplitudes during transit through the sensing region. (b) Distributions of normalized transit velocity for two groups stratified by impedance signal amplitude (Small vs. Large, relative to the reference amplitude), demonstrating a statistically significant difference between groups. (p = 0.003) (c) Scatter plot of normalized transit velocity versus impedance signal amplitude for individual cells, showing a weak overall correlation.

Figure S7

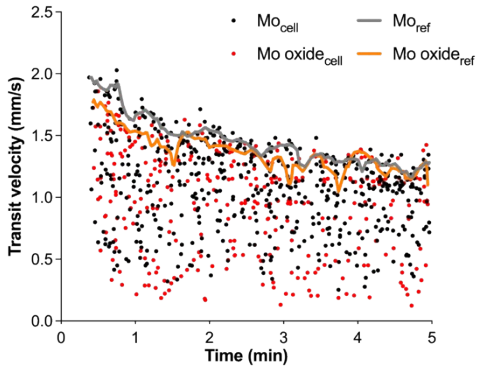

Figure S7. Scatter plot of transit velocities for Mo and Mo oxide samples. The reference velocity is defined as the mean of the top 20% of measured values. Velocities measured on Mo electrodes are shown in black, and those on Mo oxide electrodes are shown in red. Reference velocities for Mo and Mo oxide samples are indicated by gray and orange lines, respectively.

Table S1. Measured morphological features and electrical signal characteristics of the five individual RBCs shown in **Fig. S2**. For each cell, the projected cell area, aspect ratio, signal amplitude, and transit velocity are presented.

Cell	Projected area (μm^2)	Aspect ratio	Signal amplitude (a.u.)	Transit velocity (mm/s)
1	91	1.049	165.5	3.00
2	108	1.148	209.5	2.86
3	116	1.065	196	2.86
4	93	1.191	146	2.86
5	106	1.033	199.5	2.70