Cell Migration on Microposts with Surface Coating and Confinements

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Cells encounter complex three-dimensional (3D) extracellular matrix (ECM) with different physical dimensions and confinements in vivo. The surrounding microenvironment could influence cell spreading and migration. Previous studies have only demonstrated the confinement effects on cell migration in uniform collagen fibers. To study cell migration under various degrees of confinements and different coating conditions, platforms with micropost arrays with controlled fibronectin (FN) protein coating and top covers were developed.

Polydimethylsiloxane (PDMS) microposts were selectively coated with FN on top using contact printing, as shown in Figs. 1 (a)-(b). Compared to unconfined cell migration shown in Fig. 1 (a), vertical confinement was added by bonding a cover above the post arrays, as shown in Fig. 1 (b). To further investigate the effect of confinement smaller than the cell size, FN was coated all over the microposts and cells could migrate in between the sidewalls of the densely packed microposts, as shown in Fig. 1 (c). Figure 1 (d) shows the micropost arrays bonded with a cover and FN was coated on all surfaces inside the sealed channel. In this case, cells could migrate in the 10/20 μm space above the microposts or squeeze in the 3/5 μm space between the microposts.

Figure 2 (a) shows how MC3T3-E1 cells only spread and contacted the top surface of microposts if FN was coated on top. The cell nucleus was round and the actin-filaments were developed around the cell body. In comparison, the cells contacted the sidewalls of microposts and lamellipodia were observed to protrude between the microposts, as shown in Fig. 2 (b). The cell nucleus was deformed and the actin-filaments were observed to extend in between the microposts. It suggested that different migration mechanisms occurred for cell migrating in tightly confined space. Cell migration trajectories and speed were largely affected by the confinement in the platforms. Figure 3 (a) shows cell migration direction was random on microposts with FN coated on top. When FN was coated all over, the cell migration was affected by the arrangement of the micropost arrays and it had more limited range, as shown in Fig. 3 (b). With a 20 μm high cover, the cell migration trajectories were similar to unsealed platform, as shown in Fig. 3 (c). When further reducing the channel height to 10 μm, cell migrated faster with a much greater range, as shown in Fig. 3 (d). Compared to cell migration on top of the microposts, Fig. 3 (e) shows cell motility reduced when cells were confined by the sidewalls of microposts. Adding a 10 μm high cover increased the cell migration speed increased significantly to 0.84 ± 0.14 μm/min.

These results show MC3T3-E1 cell morphology, migration speed, and directionality were affected by various degrees of 3D confinement. The controlling of protein coating and addition of cover can influence cell migration range and speed, which will be useful for designing in-vitro migration platform to control cell migration in confined microenvironment.

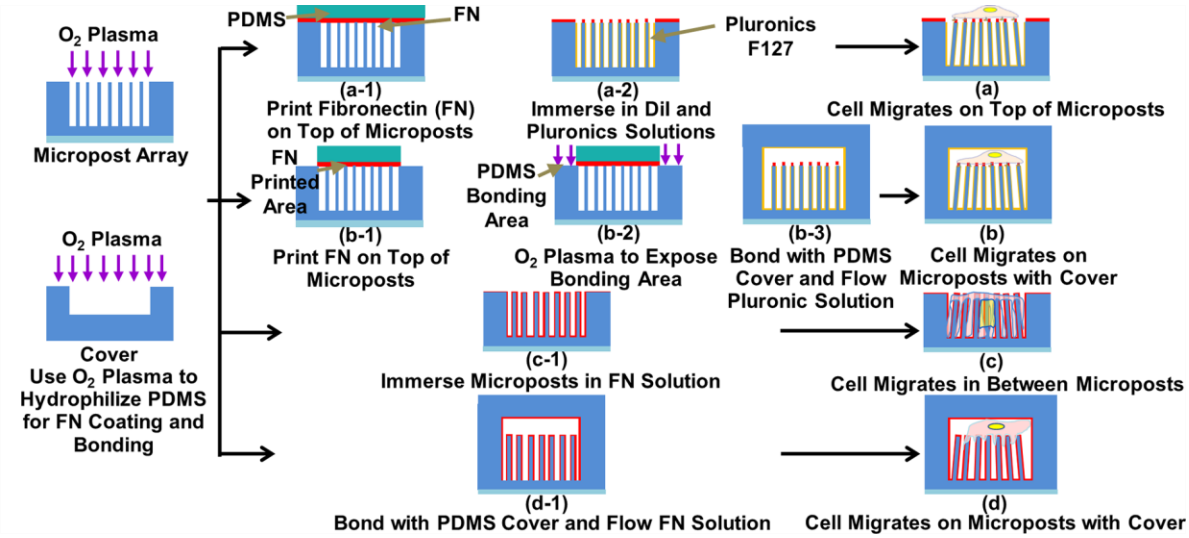

Figure 1: Fabrication technology for cell migration platforms. (a) FN coated on top and cells migrated on top. (b) FN coated on top with cover. (c) FN coated all over and cells squeezed in between posts. (d) FN coated all over with cover.

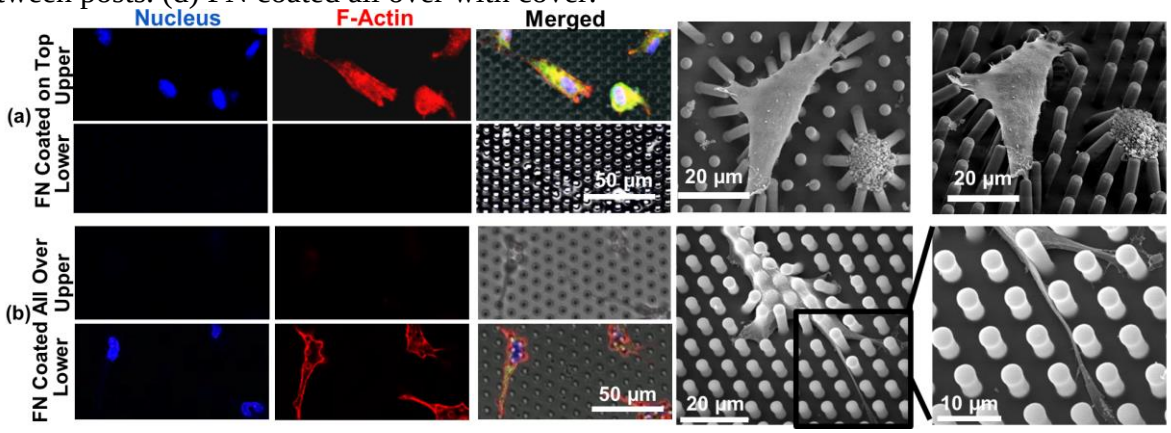

Figure 2: Immunefluorescent and scanning electron micrographs showing cell spreading on microposts with 5 μm spacing: FN coated (a) on top and (b) on all surfaces.

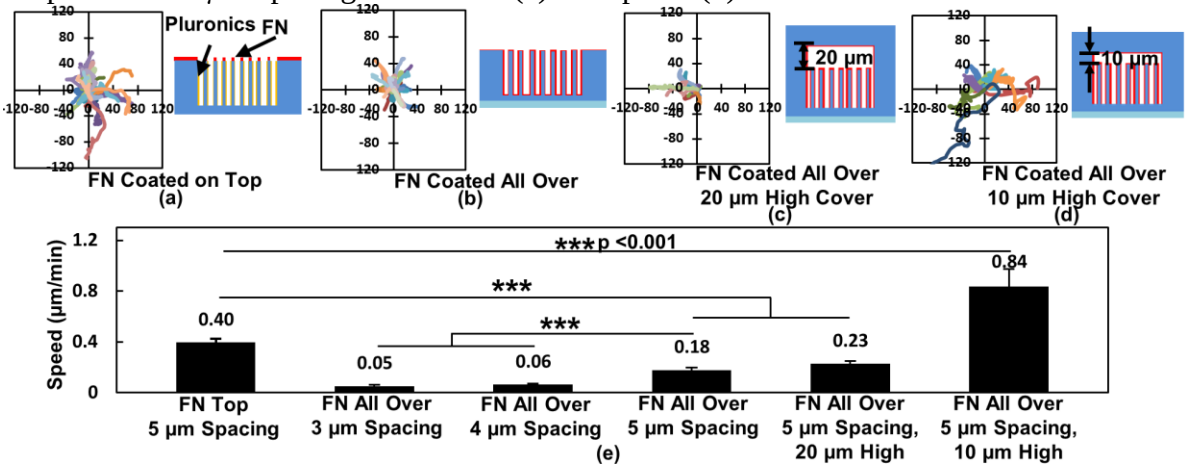

Figure 3: Cell migrations trajectories on micropost platforms: (a) FN coated on top, (b) FN coated all over, (c) FN coated all over with 20 μm high cover, and (d) FN coated all over with 10 μm high cover. (e) Cell migration speed on micropost platforms with different confinements.