Cell Migration Directionality Control by Transitions on Patterned Substrates

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Cell migration plays a key role in many physiological and pathological processes, such as cancer cell metastasis and wound healing. The migration of adherent cells has been demonstrated to be influenced by surface topography of substrates. However, the knowledge on cell migration directionality is limited.

In this study, we have developed patterns that can affect the direction of cell migration. Polydimethylsiloxane (PDMS) was applied as the engineered substrate for cell culturing. Patterns consisting of gratings, triangles, and semicircles were fabricated in Si and transferred onto PDMS substrates. The samples were exposed to an O_2 plasma to form hydrophilic PDMS surface. MC3T3-E1 cells were seeded at 10^3 cells/cm^2 on these platforms, and were maintained in Dulbecco's modified eagle medium with high glucose, 10% fetal bovine serum, 1% antibiotic-antimycotic, and 1% L-glutamine.

It can be seen from Fig. 1(a) that cells can be guided on triangular pattern with 1 μm gaps, but the pattern guiding capability decreased when the gaps were increased to 5 μm (Fig. 1(b)). Continuous grating and semicircular patterns in Figs. 1(c) and 1(d) both show good cell guidance. Figure 2 shows directional change of cells on different patterns. All cell (100%) changed direction at least once on triangular pattern with 5 μm gaps in 900 min, but only 62% of the cells had changed direction on similar pattern with 1 μm gaps. For continuous gratings, cells had less directional changes (35%). The least directional change was found on semicircular pattern (28%), where cells maintained high directional persistence. The results indicate that cell migration directionality can be controlled by designed patterns.

Figure 3 shows a time sequence of a MC3T3-E1 cell moving on a semicircular pattern in 60 min. The leading edge of the cell elongated along the edge of the semicircles, and followed the curvature of the pattern. Further study will be carried out to identify the critical factors that influence cell migration to allow the design of selectively patterned surface to control the cell migration directionality.

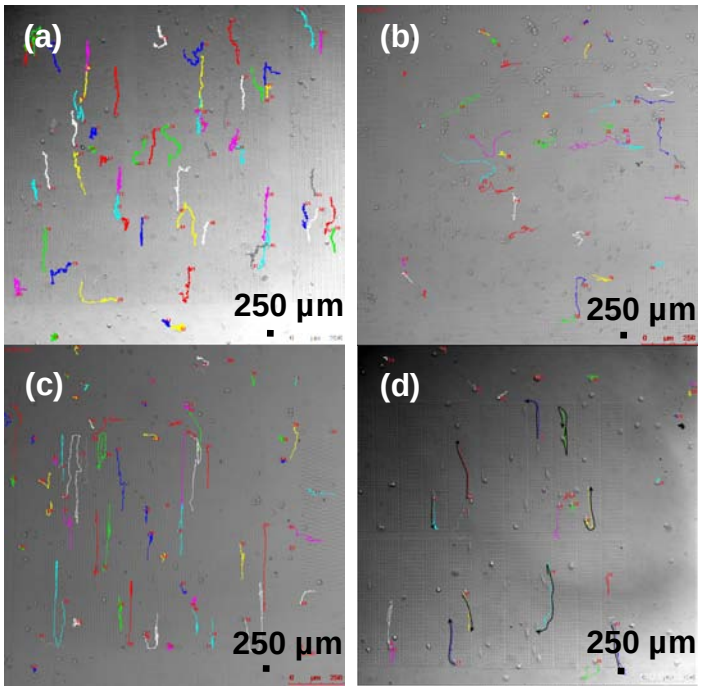

Figure 1 Tracking of movement of MC3T3-E1 cells on (a) triangular pattern with 1 µm and (b) 5 µm gaps; (c) gratings; and (d) semicircles.

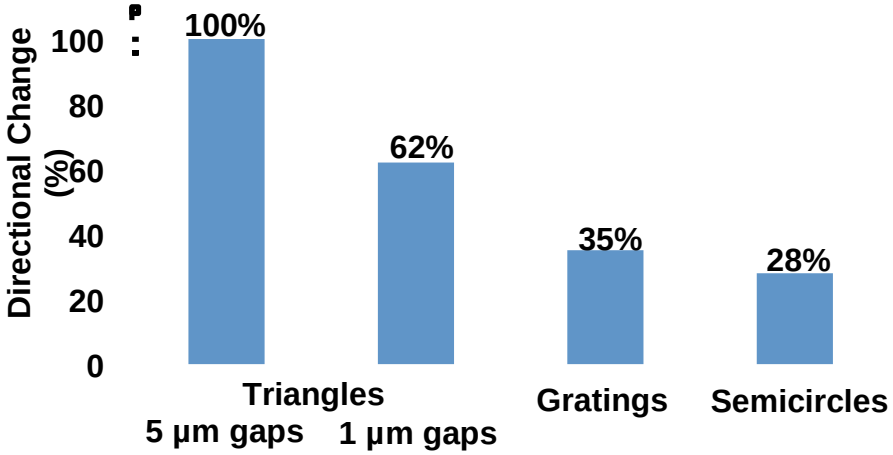

Figure 2 Percentage of directional change of MC3T3-E1 cells on triangular patterns with 1 and 5 µm gaps, gratings, and semicircles.

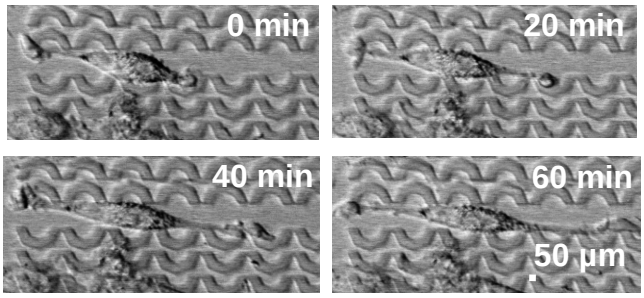

Figure 3 Leading edge of MC3T3-E1 cell moving along curvature of semicircles.