Influence of Engineered Surface on Cell Motility and Directionality

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Providing a platform for cell growth and guidance is desirable to generate artificial tissues or to eliminate harmful cells. Although contact guidance by micro- or nano-patterns is known to affect cellular behaviors such as alignment, morphology, and differentiation, the motility and directionality of cell movement are less known. In this paper, patterned structure effects including groove width, depth, and shapes on cell motility and directionality will be investigated.

Polydimethylsiloxane (PDMS) was applied as the engineered substrate for cell culturing. Different patterns consisting of gratings, circles, posts, grids, and boxes with different angles were fabricated in Si and transferred onto PDMS substrates. An O_2 plasma was used to form a hydrophilic PDMS surface. MC3TC-E1 (ATCC CRL-2594) cells were seeded at 10^3 cells/cm^2 on the PDMS structures, and were maintained in Dulbecco's modified eagle medium with high glucose (Invitrogen, 11995-065), 10% fetal calf serum, and 1% antibiotic-antimycotic (Invitrogen) for culturing.

It can be seen from **Fig. 1** that the cells were guided along the circular and angular grooves. The 5 μm wide grooves provided effective guiding of cells. **Figure 2** shows time-lapsed images of cells on these patterns compared to those on a flat surface. Cells seeded on the patterned area moved faster and changed their positions along the patterns. However, cells seeded on a flat surface tend to stay where they were and travelled a shorter distance. As shown in **Fig. 3**, the total distance travelled by the cells seeded on patterned area is more than 2 times longer than that of cells on a flat surface in 22 hr. Although the cells moved faster on the patterned area, the displacement, which is defined as the position offset of a cell from the beginning to the end, is similar. From the above results, the cells' speed and directionality could be tuned by the underlying patterns.

The cells behavior at transition location is shown in **Fig. 4**. The highlighted cell moved along the patterns and followed the turn of the 135^o corner as shown in Figs. 4(a) to 4(c). But the cell bounced back when it got to the end of the patterns as shown in Figs. 4(d) to 4(f). This phenomenon could be utilized to change the direction of cells and provide guidance. Additional results including the effects of the pattern dimension, design, transition region, and surface energy on cell motility and directionality will be presented.

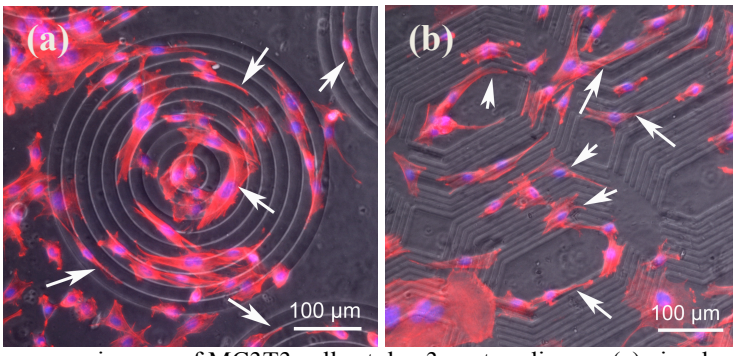

Figure 1: Fluorescence images of MC3T3 cells at day 3 postseeding on (a) circular and (b) angular structures in PDMS with 5 μm wide, 1 μm deep grooves.

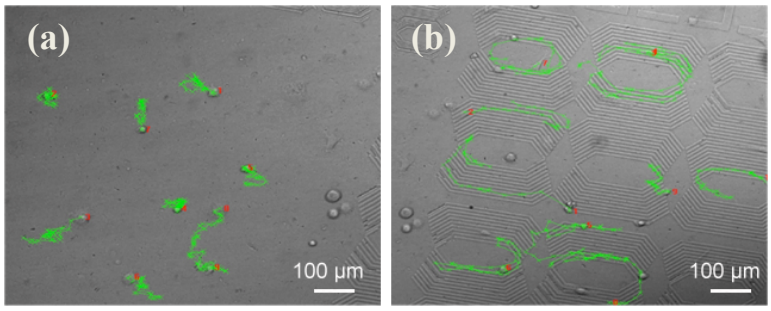

Figure 2: Images of time-lapsed paths of MC3T3 cells in 22 hr. Red color marks the starting points of cells and green trails represent cell passages on (a) flat surface and (b) patterned surface.

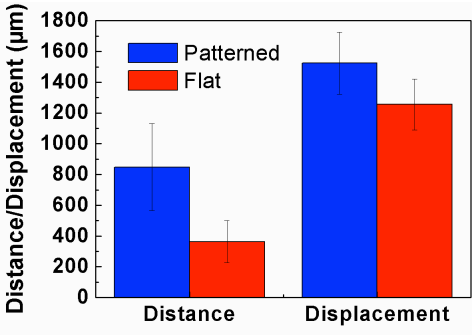

Figure 3: Effects of patterned structures on cell travel distance and displacement.

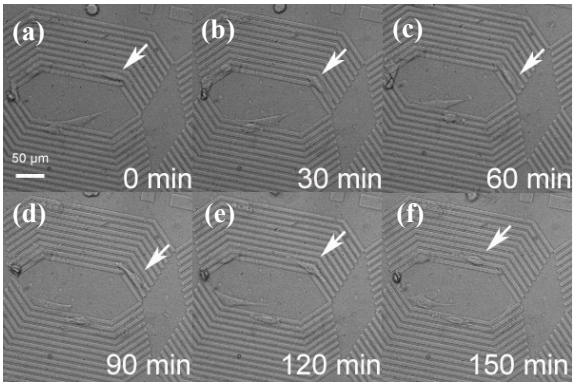

Figure 4: Movement of cell along angular patterns (a-c) and it bounced back when patterns ended (d-f).