Electronic Supplementary Material (ESI) for Lab on a Chip.

Video S1. Beads trapping process using steel beads, through-hole plates, and magnet array. A 750 μm through-hole array (50 x 50) plate, a 550 μm through-hole array (50 x 50) plates and a magnet array (30 x 30) were sequentially stacked. Then 600 μm steel beads were poured and spread on the top plate to have each through-hole take one steel bead which was fixed stably by the magnetic force of the magnet array as well as by the through-hole structure. The excessive beads were removed first by scrapping with a plastic plate and second by using another neodymium magnet (diameter = 15 mm, thickness = 2 mm). The 750 μm hole plate (top plate) was then separated.

Video S2. Bead's motion on the magnet array. A transparent polycarbonate film (thickness = 200 μm) was placed on the magnet array. Then a steel bead (diameter = 600 μm) was carefully dropped on the film. This video shows that the bead always moves as guided by the magnetic field and positions onto the center of top area of a magnet. Also see figure S3 for the computed magnetic field in the magnet array..

Figure S1. Removal of excessive cells by receding meniscus. By surface tension between medium and air, the cells on the substrate surface were scrapped leaving the cells trapped in microwell and removing excessive cells.

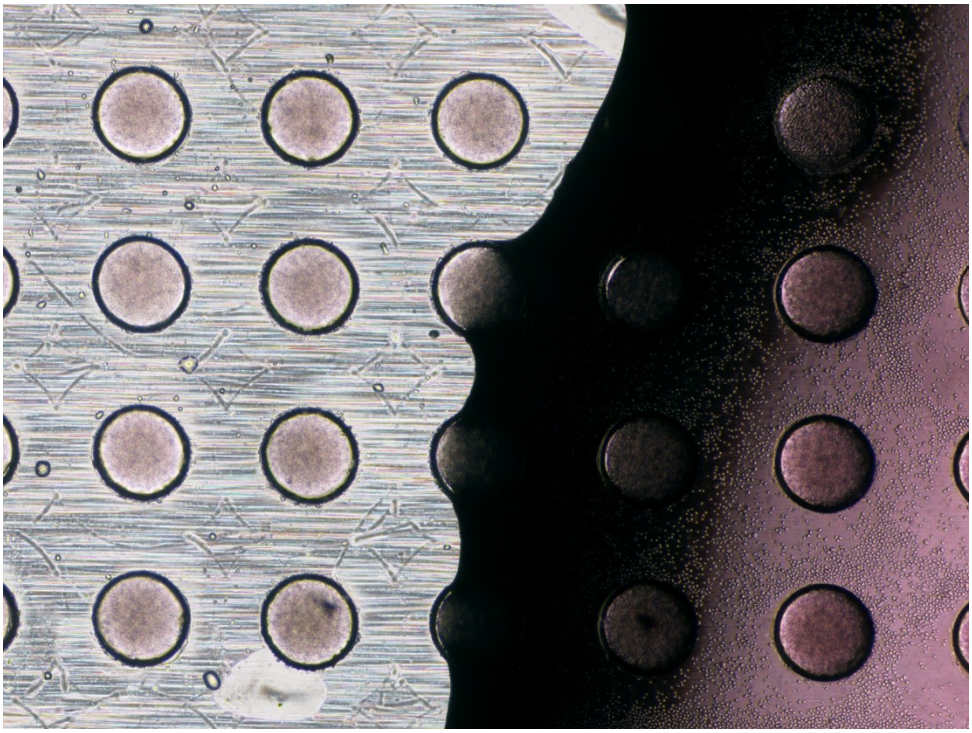

Figure S2. SEM images of different PDMS substrates show consistent size and shape of microwells since uniform-sized commercial steel beads were served as a mold. Scale bars are 1 mm.

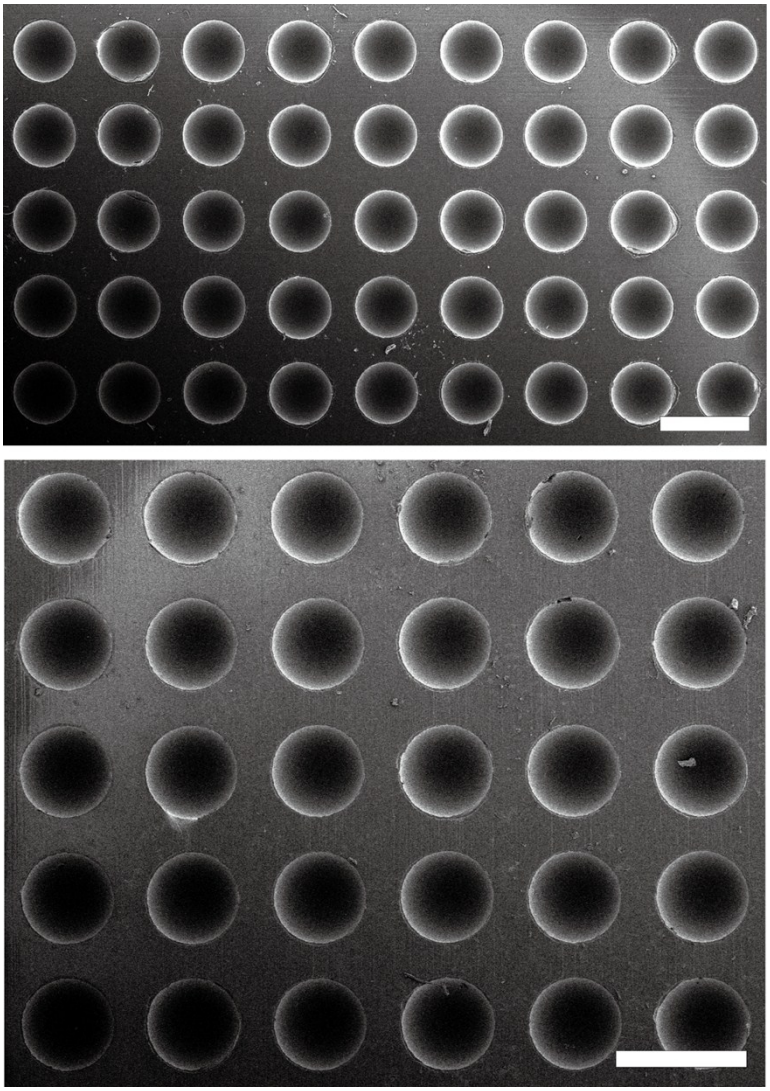

Figure S3. Computed magnetic field distribution for magnet array. Neighboring magnets have alternating polarity. Horizontal magnetic field is dominant at the border of neighboring magnets and vertical magnetic field is strong at the center of each magnet. Such directional forces guide a bead to the center of a magnet.

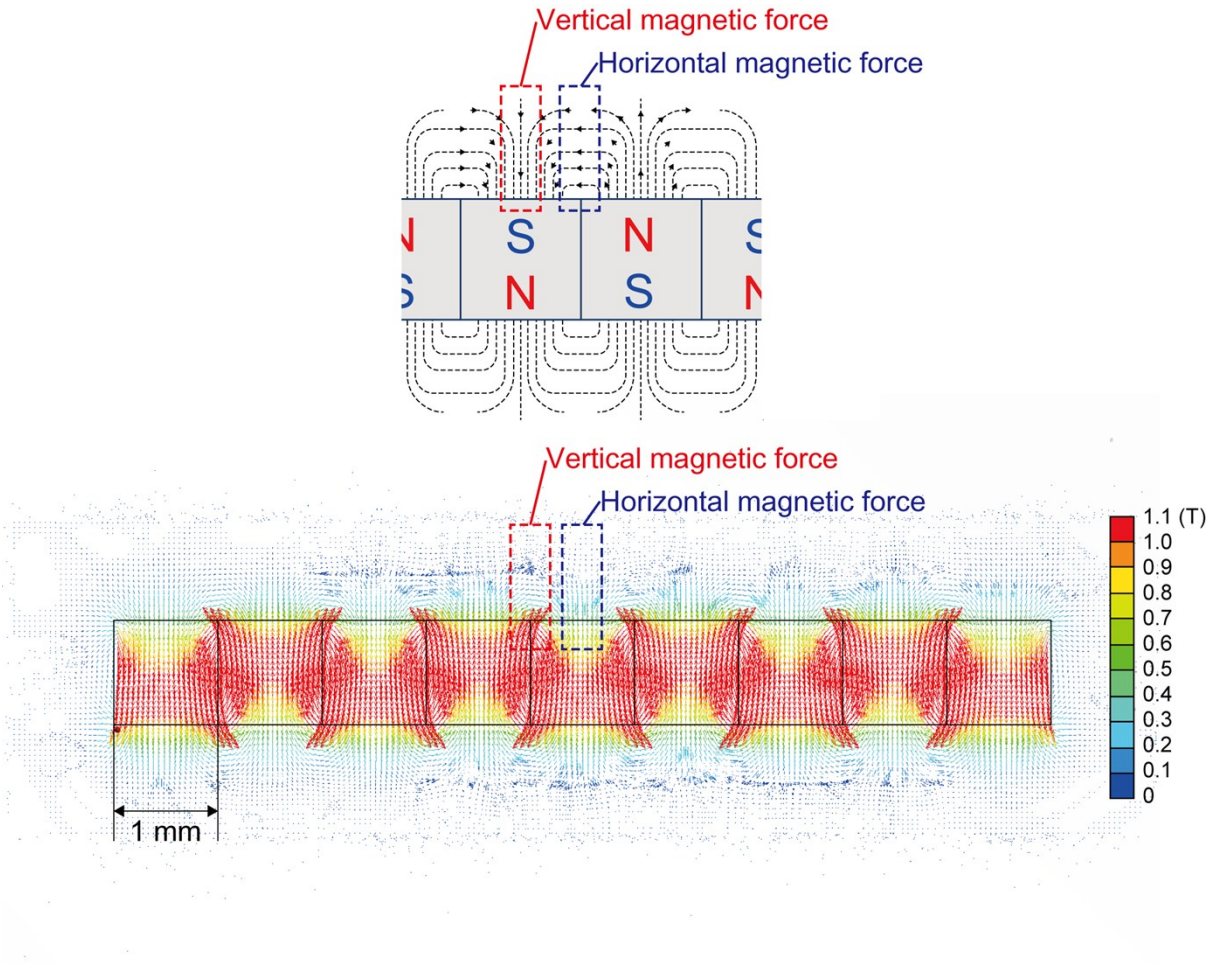

Figure S4. SEM images show cracks and wrinkles on the outer surface of microwell substrate. These cracks and wrinkles were created during bead removal process. Scale bars are 500 μm.

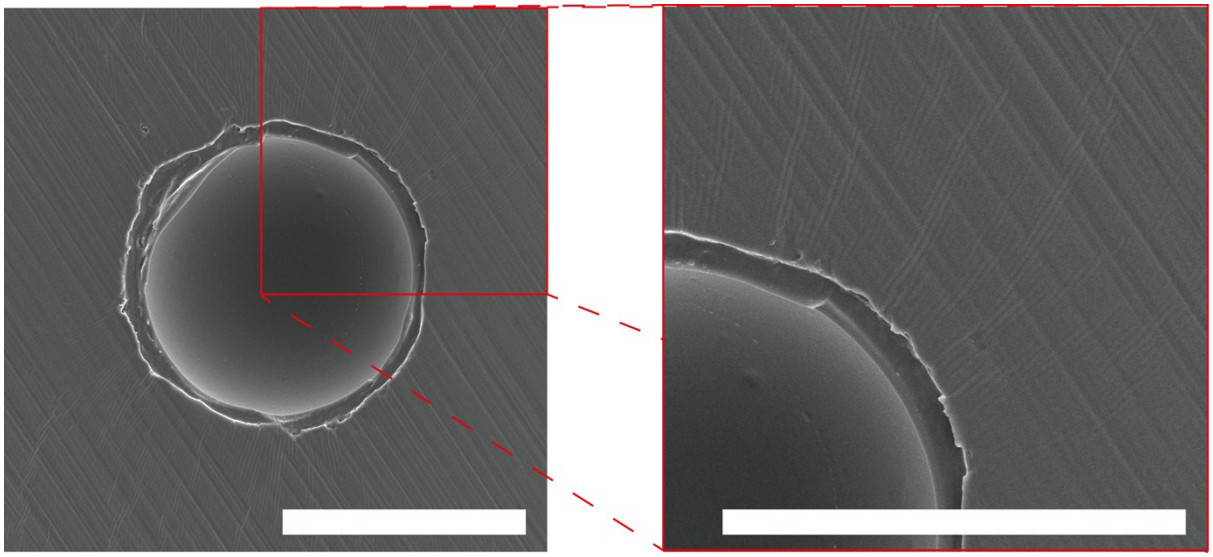

Figure S5. RT-PCR analysis of gene expression in hASC. Compared with single-layer conditions (G1), a turn to spheroidal culture condition (G2) showed up-regulation of several genes including COL2A1 chondrocyte specific marker. RT-PCR products were determined by agarose gel electrophoresis.

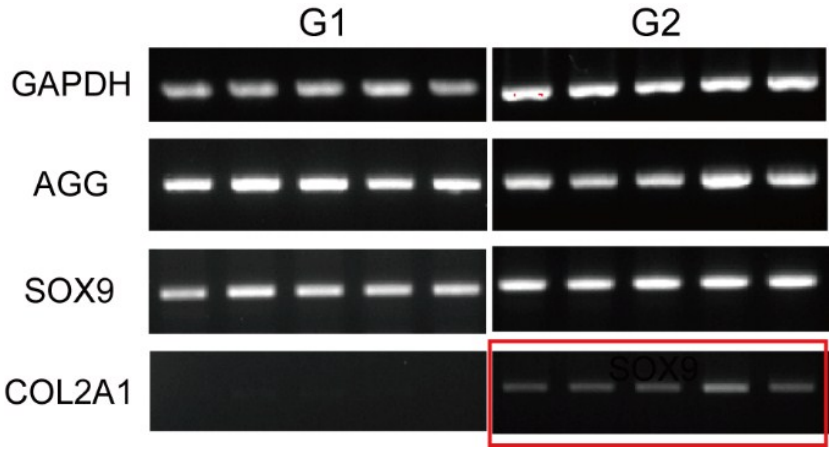

Table S1. Primers used for RT-qPCR (the initial q- means sequences used for quantitative PCR).

Gene	*Forward primer*	*Reverse primer*	*Tm (℃)*
GAPDH	5' - CGG ATT TGG TCG TAT TGG GC – 3'	5' - CAG GGA TGA TGT TCT GGA GA - 3'	58
Aggrecan	5' - GAA TCT AGC AGT GAG ACG TC – 3'	5' - CTG CAG CAG TTG ATT CTG AT - 3'	49
Collagen Type Ⅱα-1	5' - TTC AGC TAT GGA GAT GAC AAT C – 3'	5' - AGA GTC CTA GAG TGA CTG AG - 3'	56
SOX-9	5' - TGA AGA AGG AGA GCG AGG AG – 3'	5' - GCG GCT GGT ACT TGT AAT CC - 3'	57
q-GAPDH	5'- ACA TCG CTC AGA CAC CAT G-3'	5'- TGT AGT TGA GGT CAA TGA AGG G-3'	-
q-Aggrecan	5' - GCC TGC GCT CCA ATG ACT – 3'	5' - ATG GAA CAC GAT GCC TTT CAC - 3'	-
q-Collagen Type Ⅱα-1	5' - CAC GTA CAC TGC CCT GAA GGA – 3'	5' - CGA TAA CAG TCT TGC CCC ACT T-3'	-
q-SOX-9	5' – CCC CAA CAG ATC GCC TAC AG -3'	5' – GAG TTC TGG TCG GTG TAG TC -3'	-