

Table S1. HUVEC Cell exfoliation rate after mechanical treatment

| Cell number actual value (theoretical value) $\times 10^4$ | | | | | |
|--|-----------|--------------------|------------------|--------|---|
| Time | Treatment | Unexfoliated cells | Exfoliated cells | Total | Result |
| 24h | Control | 6.25 (6.22) | 0.75 (0.78) | 7.00 | $\chi^2 = 3.73848388$ $P = 0.154240541$ |
| | SMG | 9.67 (11.48) | 3.25 (1.43) | 12.92 | |
| | OL | 26.75 (24.96) | 1.33 (3.12) | 28.08 | |
| | Total | 42.67 | 5.33 | 48 | |
| 48h | Control | 34.50 (31.99) | 2.75 (5.26) | 37.25 | $\chi^2 = 15.46214985$ $P = 0.000438972$ |
| | SMG | 21.00 (27.26) | 10.75 (4.48) | 31.75 | |
| | OL | 29.67 (25.91) | 0.50 (4.25) | 30.17 | |
| | Total | 85.17 | 14.00 | 99.17 | |
| 72h | Control | 69.08 (63.99) | 5.83 (10.92) | 74.91 | $\chi^2 = 92.25000581$ $P = 9.29321E-21$ |
| | SMG | 24.17 (45.84) | 29.50 (7.83) | 53.67 | |
| | OL | 114.67 (98.09) | 0.17 (16.75) | 114.84 | |
| | Total | 207.92 | 35.50 | 234.42 | |

Table S2 MCF-7 Cell exfoliation rate after mechanical treatment

| Cell number actual value (theoretical value) $\times 10^4$ | | | | | |
|--|-----------|--------------------|------------------|-------|---|
| Time | Treatment | Unexfoliated cells | Exfoliated cells | Total | Result |
| 24h | Control | 6.83 (6.61) | 0.58 (0.81) | 7.41 | $\chi^2 = 4.363168461$ $P = 0.112862589$ |
| | SMG | 8.83 (10.78) | 3.25 (1.31) | 12.08 | |
| | OL | 26.75 (25.03) | 1.33 (3.05) | 28.08 | |
| | Total | 42.41 | 5.16 | 47.57 | |
| 48h | Control | 34.50 (32.89) | 2.75 (4.36) | 37.25 | $\chi^2 = 11.45367974$ $P = 0.003257355$ |
| | SMG | 18.83 (23.47) | 7.75 (3.11) | 26.58 | |
| | OL | 29.67 (26.64) | 0.50 (3.53) | 30.17 | |
| | Total | 83.00 | 11.00 | 94.00 | |
| 72h | Control | 69.08 (71.65) | 5.83 (3.25) | 74.91 | $\chi^2 = 261.3459895$ $P = 1.77599E-57$ |
| | SMG | 24.50 (51.33) | 29.17 (2.33) | 53.67 | |

| | | | |
|----|----------------|--------------|--------|
| OL | 114.67 (98.09) | 0.17 (16.75) | 114.84 |
|----|----------------|--------------|--------|

| | | | |
|-------|--------|-------|--------|
| Total | 207.92 | 35.50 | 234.42 |
|-------|--------|-------|--------|

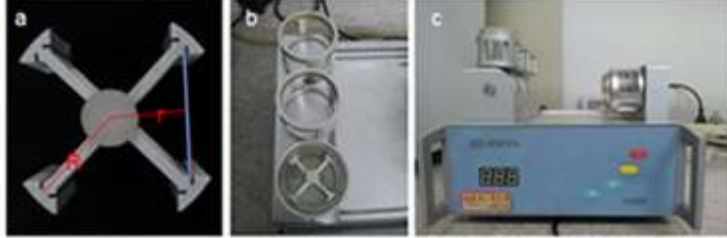


Figure S1. The experimental setup. a. Cell culture frame (the blue line indicate slip with cells). b. The culture bottle is fixed on the equipment. c. The equipment of 2D-RWVs. The culture bottle is fixed on the equipment and rotates around the horizontal axis (right) to simulate microgravity effect. The culture bottle is fixed on the equipment and rotates around the vertical axis (left) to obtain mechanical overloading.