Validation of a new device dedicated to the mechanical characterisation of cartilage micropellets

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Validation of a new device dedicated to the mechanical characterisation of cartilage micropellets

INTRODUCTION

- Articular cartilage ensures smooth motions and facilitates force transmissions.
- Cartilage micropellet is known as cartilage growth model [1].
- In literature, very few studies focus on the evolution of mechanical properties over time during growth [2].
- A new device were designed to assess mechanical properties of micropellets without removing them from their culture environment.

Objective: (i) To test if the new fluidic device damages soft microspheres subjected to large deformation and (ii) to estimate the precision of this new device to quantify mechanical properties.

MATERIALS & METHODS

- Home made device : Fluidic system with 3D-printed tank (Figure 1). Fluid pressure applied at the top causes the sphere to sink into the cone and to deform. Pressure and displacement were recorded in order to estimate mechanical properties of the beads.
- Conventional compression device : Beads were compressed between 2 planar surfaces in order to get ground values of the mechanical properties of the beads.
- Beads : 13 alginate beads (1,36 ± 0,13 mm in diameter) were made by polymerisation of a solution of 3% w/w sodium alginate in 0.15 M NaCl, in 0.1M CaCl2 during 24h.
- Chronology of mechanical tests (Figure 2) : In order to check if the beads were damaged by the large deformation with the new fluidic device, conventional compression tests were driven before and after the new fluidic test.

Figure 1 – Fluidic system of compression for microspheres.

RESULTS

- Fitted curves: Figure 4 – Experimental and simulated displacements of the bottom of an alginate bead as a function of the pressure applied at the top of the bead.

<table>
<thead>
<tr>
<th></th>
<th>Conventional compression 1</th>
<th>Fluidic compression</th>
<th>Conventional compression 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>104,7 *</td>
<td>107,0</td>
<td>97,8 *</td>
</tr>
<tr>
<td>Sd</td>
<td>29,1</td>
<td>36,0</td>
<td>19,1</td>
</tr>
</tbody>
</table>

Table 1 – Mean and standard deviation of Young’s moduli (kPa) obtained for both testing devices; * p=0,25 compared to fluidic compression test; $ p=0,31 compared to the second conventional compression test.

DISCUSSION

- No damage of alginate beads (p=0,31 between both conventional tests) : results of both conventional and fluidic compression test can be compared and the system is non destructive for the spheres.
- Similar Young’s moduli with both type of tests : new device allowed to characterise the mechanical properties of small spherical samples in a quantitative manner.
- Limitation : No perfect fit between experimental and numerical data because of a quite simple hyperelastic law.

CONCLUSION

- A new fluidic system is proposed to pressurise small soft spheres into a conical shape.
- This new setup, together with an identification procedure, is able to quantify mechanical properties.
- Fabricated with fully biocompatible materials, this new device should be able to mechanically stimulate and to follow up mechanical properties of cartilage micropellets.

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REFERENCES