A BIOREACTOR TO INVESTIGATE THE MECHANICAL INFLUENCE ON CELL MINERALIZATION IN LATTICE BONE IMPLANTS

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Introduction

Bone implants require a considerable period of time until they become integrated within the native bone [1]. In this context, implants with lattice structures are becoming increasingly interesting because of their macroporosity and thus potentially improved osteoconductive properties [2, 3]. However, understanding the implant's healing dynamics and its dependency on mechanical loads necessitates knowledge of how cells behave within the lattice geometries. Therefore, a bioreactor reproducing mechanical loads on cell-seeded lattice structures, concurrently allowing mechanical properties measurement over time as results extracellular bone matrix calcification would be valuable. This work presents such a bioreactor design and its working principles.

Methods

A reservoir for a human mesenchymal stem cell culture was manufactured using 3D printing with biocompatible resins. The rod-shaped material samples were also 3D printed, including lattice structures, that can be inserted into this reservoir. A pneumatic cylinder was installed to induce controlled deformation at one end of the samples, which were thus subjected to bending. A load cell and temperature-compensated bridge circuit were incorporated to measure the force exerted by the pneumatic cylinder on the lattice samples. A microcontroller was employed to dictate the stimulation patterns and store the measurement results.

Results

The bioreactor can accommodate a total of twelve rod-shaped samples with a size of $50\times8\times5$ mm^3. Among these, six samples can be bent with a stroke of up to 5 mm. The remaining six samples are not stimulated and serve as a control. All stimulated samples are attached to a single axis, and the force on all six samples is measured collectively. The load cell can handle a force of up to 50 N, which can be measured with a resolution of 24 bits. The entire bioreactor can be housed in a static incubator. The bioreactor features a lid with air filters to prevent contamination while allowing air circulation. Only thin cables for measurement and a hose for compressed air need to be led into the incubator, while all other components remain outside. There is no exchange of air between the incubator and the compressed air for the pneumatic cylinder.

Discussion

The bioreactor has successfully undergone and passed a 72-hour durability tests and the first cell experiments with this bioreactor will begin shortly. This bioreactor enables both static and dynamic mechanical testing. Moreover, the samples can be easily extracted, enabling further examination, such as microscopical analysis and staining to detect calcium deposits. This also includes the possibility to evaluate cell responses to mechanical stimuli in both static and dynamic conditions. We anticipate obtaining insightful findings about the alterations in lattice structures induced by bone cells. Insights that would have been unattainable without the aid of such a specialized bioreactor.

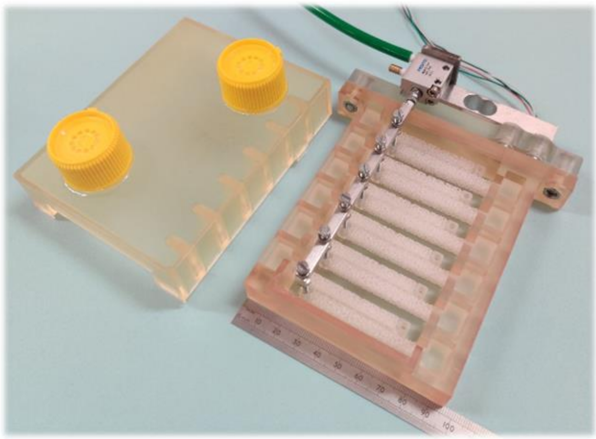

Figure 1: Photo of the bioreactor. Placed on the left side is the lid with ventilated caps. The bioreactor on the right side of the image contains 12 specimens with lattices, of which 6 will be mechanically stimulated. Attached to this is the pneumatic actuator and the load cell to measure the force applied to the specimen.

References

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