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Development of a Multiaxial Cartilage Bioreactor on Basis of a Wear Simulator of the Knee

Gait motion as physical stimulation in a bioreactor, proving the suitability of rehabilitation protocols within chondrogenic cells in vitro

Reference: Multiaxial Cartilage Bioreactor

Source: Racle Fotodesign, stock.adobe.com/uk/49010117, stock.adobe.com

Seeking

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About **LMU Munich**

Ludwig-Maximilians-Universität München is the University in the heart of Munich. LMU is recognized as one of Europe's premier academic and research institutions. The LMU Munich community is engaged in generating new knowledge for the benefit of society at large.

Background

The great benefit that multiaxial load brings to the development of tissue-engineered cartilage is demonstrated in multiple studies. In addition, the verification of rehabilitation of cartilage tissue in test conditions closer to the *in vivo* situation results in more transferable results especially when it comes to cartilage development based on cells *in vitro*.

Nevertheless, modern multiaxial bioreactors stimulate the tissue-engineered construct just with an approximation of the native movement. Moreover, at the moment, bioreactors mainly use for this purpose only one direction (i. e. compression) which mostly is induced with hydrostatical compression. Altogether, these bioreactors ignore position related compression and shear which is known highly to influence the mechanical properties.

Nowadays, physiological stresses are defined and validated to the *in vivo* situation for implant-testing machines to guarantee the survival of the product while in use. So far, the combination of normative defined stresses out of these references (ISO 14243-1, ISO 14243-2, ISO 14243-3) and the need of physiological stimulation in the development of tissue-engineered cartilage construct and the suitability of rehabilitation protocols are not implemented and researched.

Tech Overview

As an example in figure 1, a multiaxial bioreactor stimulates tissue-engineered constructs in multiple directions.

Limitations of these bioreactors:

This application is still an approximation to the physiological knee movement (Fig. 2). The movement of the knee is depending on the anatomical geometry of the joint and the position of the defect and is even more complex than applied in contemporary multiaxial bioreactors.

Biomechanical approach for TKA implant testing:

To generate physiological patterns and test the amount of wear in artificial arthroplasties, these motions are applied in implant testing machines (Fig. 3). The servohydraulic driven simulator rebuilds the proposed movements of the normative references (ISO 14243-1, ISO 14243-2, ISO 14243-3) in relation to the native knee, in force control or in displacement control.

Project aim:

Combining the gait (wear) simulator and the bioreactor approach for tissue regeneration to develop tissue-engineered cartilage with mechanical properties equal to in-situ.

Methods:

To use the wear simulator as a bioreactor with the possibility of multiaxial stimulation, the existing control of movements needs to be adjusted to the needs of the tissue-engineered constructs. A ceramic femur prosthesis needs to be embedded in the system as stimuli applicator and, the reactor chamber (Fig. 4) needs to be modified to seize smaller volumes of solution.

Stage of Development

Developed already: The biomechanical simulator is already part of the inventory of the Biomechanical Laboratory. In addition, the chondrogenic potential of Pellet Cultures was investigated and established in the laboratory.

Next aim within this project: Multiaxial bioreactor development for tissue-engineered cartilage regeneration.

Benefits

- Combination of gait (wear) simulator and the bioreactor approach for tissue regeneration to develop tissue engineerd cartilage
- Tissue-engineered cartilage with mechanical properties equal to *in situ* cartilage

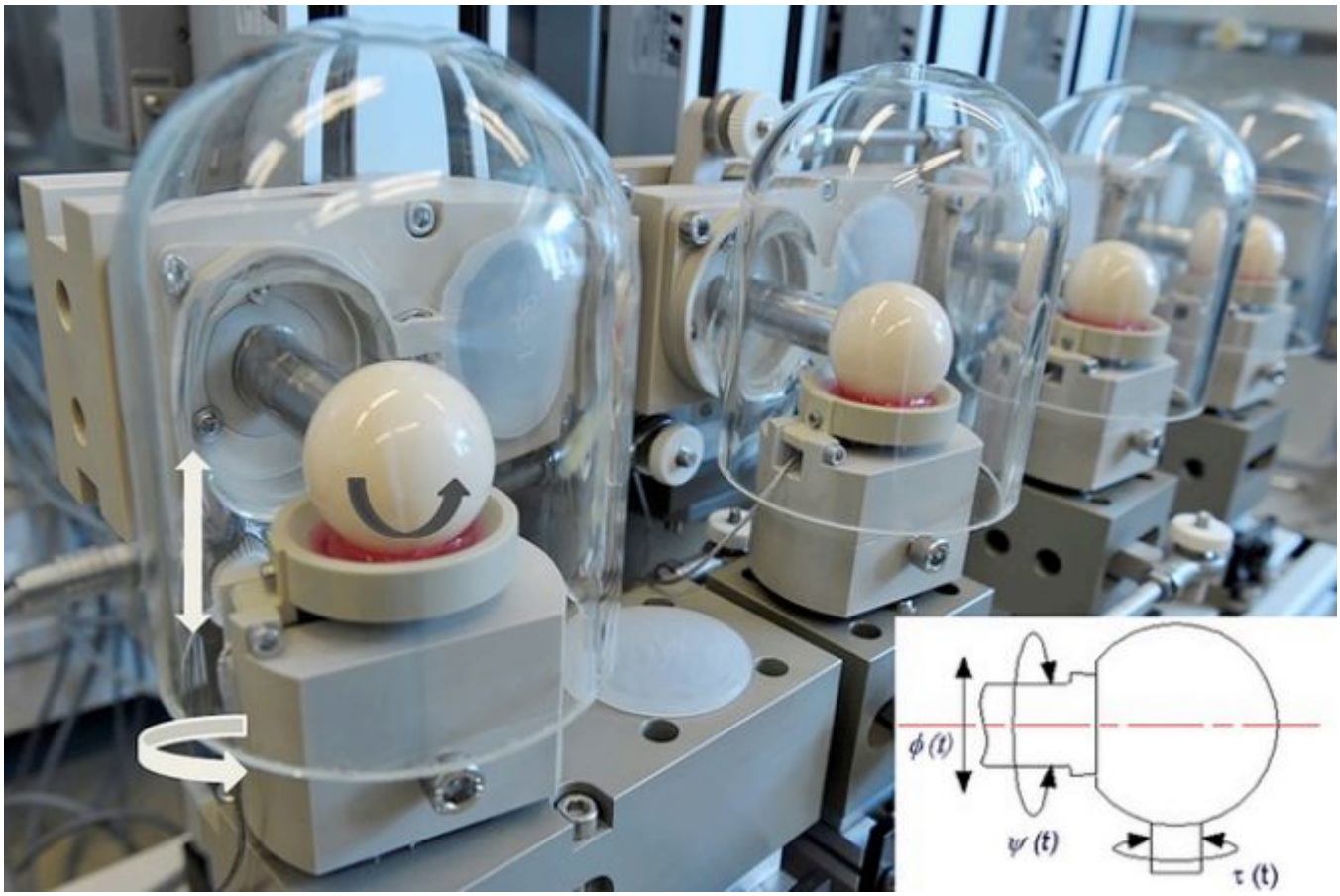
Applications

- development of tissue-engineerd cartilage

Appendix 1

figure 1

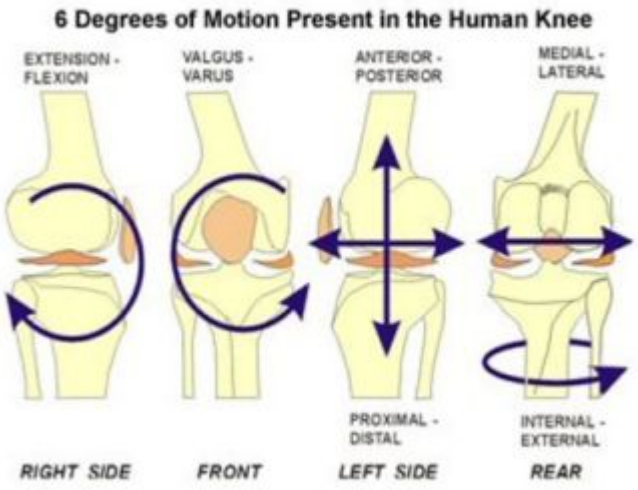
Stations of the joint bioreactor that allow the application of joint-specific biomechanical stimuli.



Appendix 2

Fig. 2

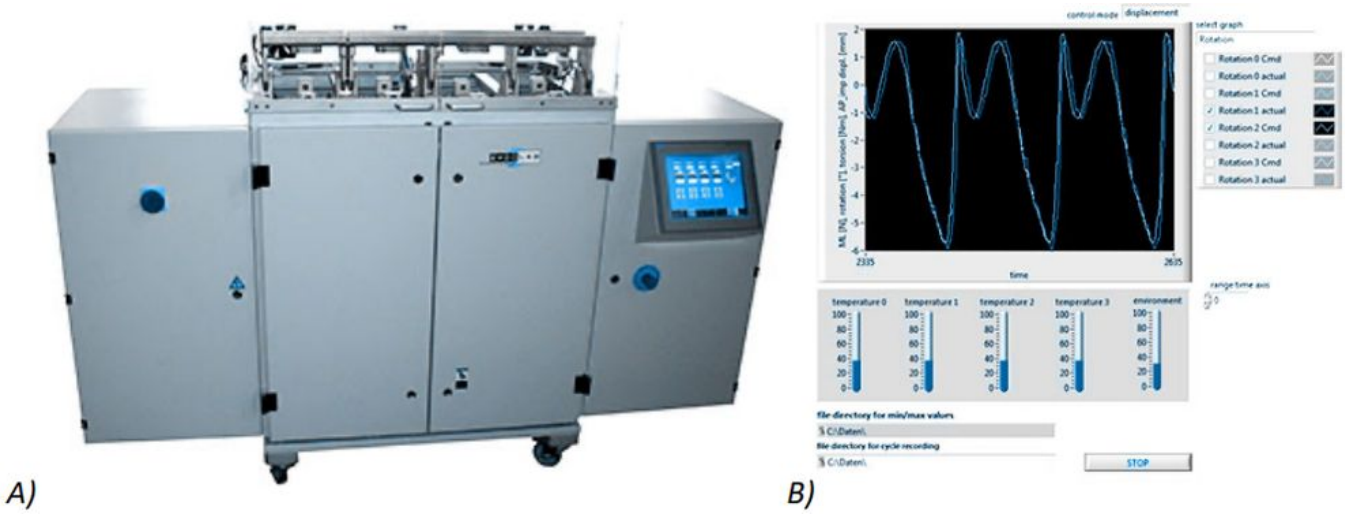
Full range of motions of the human knee.



Appendix 3

Fig. 3

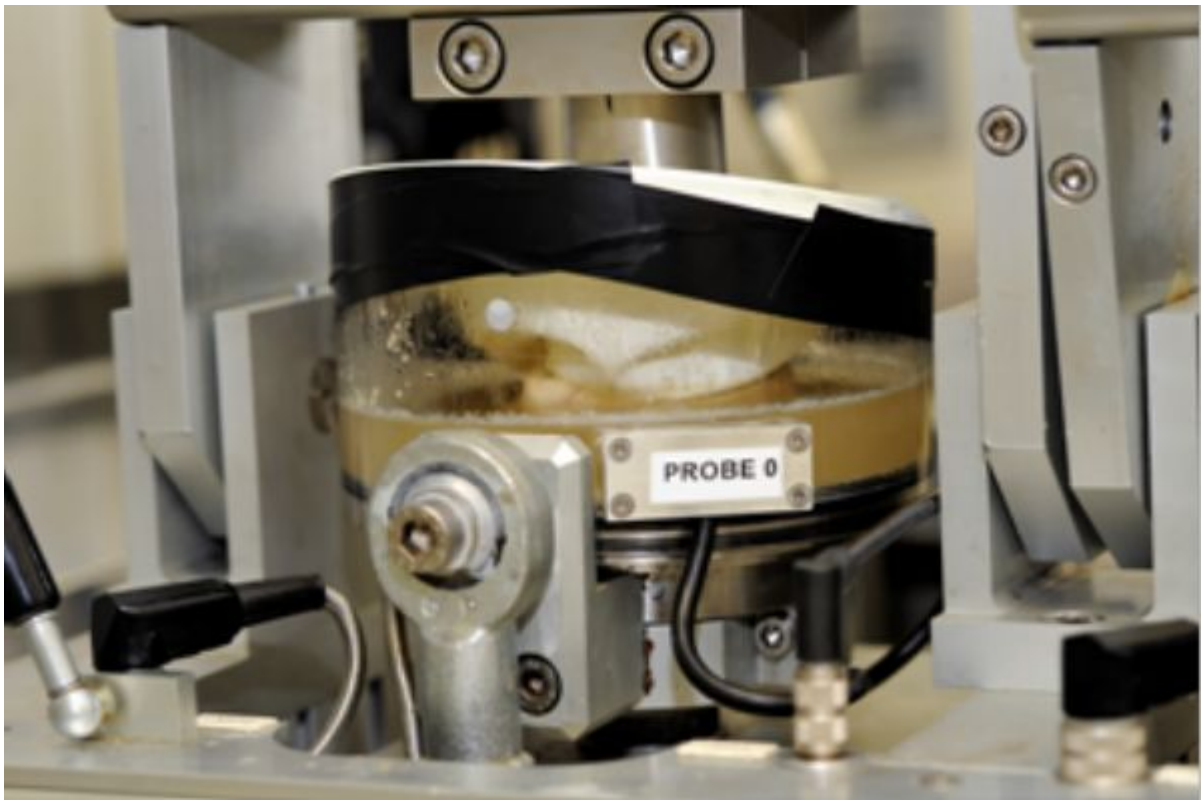
A) Four station knee wear testing machine, B) displacement and temperature control of the stations.



Appendix 4

Fig. 4

Representative image of one station of the wear simulator, showing a huge temperature-controlled chamber to lubricate the artificial joint with calf serum (protein content of 20 g/l)



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