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Flow in cancellous bone

Project ELyT lab : Poster Session

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Abstract:

1. Introduction

Stem cells in bone marrow are used for regenerative medicine. e.g. Reproduction of a part of organ cells, treatment for leukemia. And they are harvested by puncturing cancellous bone in the ilium of the donor with a needle [1]. However, this method is inefficiency, 50-100 times of puncture are needed to harvest enough stem cells. Eventually, this method increase the burden on donor. We can consider that the flow in cancellous bone has strong infulence on the volume of harvesting bone marrow. So, we calculated the flow in cancellous bone by Computational Fluid Dynamics (CFD) analysis. Then, we compared the permeability between CFD and experiment, to validate the results of CFD.

2. Experimentation, discussion

The porcine ilium which is after 1 or 2 birth was got from meat processing company. We removed fats into bone and cut it into cylinder (11 mm diameter, 19 mm length). The geometry was scanned using a micro-CT with resolution of 38.5 μm. Then the cancellous bone model was reconstructed by medical visualization software OsiriX. And, the STL file was exported, and modified by The 3D CAD software Pro/Engineer (PTC, US) and The STL editor software Magics (Materialize, Belgium). To reduce the calculation time, we selected the center of the bone (2*2*3[mm^3]) as the geometry for CFD analysis. Water was used as fluid. Figure.1 shows the schmetic of geometry. Fluid domain was set around bone(2.5*2.5*3.5[mm^3]). Wall was set noslip condition. Then mesh was generated in ICEM

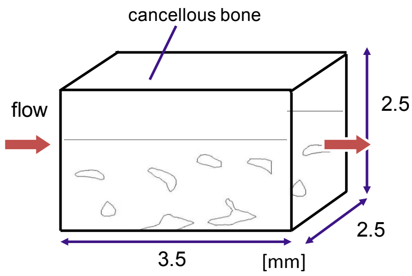

Fig.1: Image of geometry for CFD

CFD. Approximately the number of mesh is 4.3 million. Mesh type (or element) is tetrahedral and prism. We calculated flow with changing the pressure boundary condition.

Figure.2 shows the stream lines as an example of the results of CFD analysis. We can see the flow along the complex bone geometry.Figure.3 shows the correlation between Pressure drop per length and velocity. We calculated the permeability of cancellous bone based on Darcy's law.

$$k = Q\frac{\mu}{A}\frac{L}{\Delta P} \quad (1)$$

k means permeability. Q means volumetric flow rate. μ means viscosity. A means cross section of area. L means length to flow direction. ΔP means pressure drop. Permeability describes the ability of a material to transmit fluids. This is one of the important parameter for porous media such as cancellous bone. The permeability in CFD analysis is 3.16×10^{-9}. However, the permeability in experiment is 1.11×10^{-10}[2]. There is a difference between the results [3]. The trimming for being shorten calculation time can be considered a cause. So, we have to calculate a flow using bigger size of bone geometry.

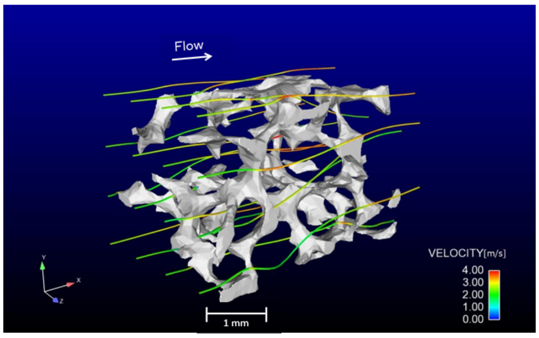

Figure 1: Stream lines

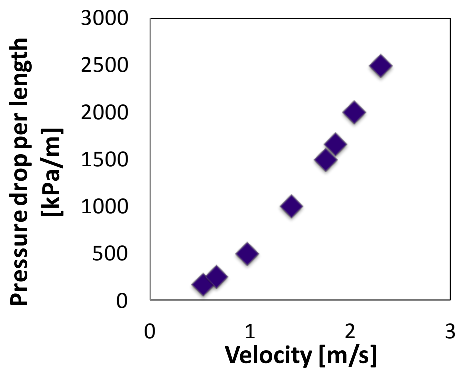

Figure 3: Correlation between Pressure drop per length and Velocity

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