Matrix distribution and the functional development of tissue engineered cartilage

technische universiteit eindhoven

Matrix Distribution and the Functional Development of Tissue Engineered Cartilage

B.G. Sengers, C.W.J. Oomens, F.P.T. Baaijens
Biomechanics and Tissue Engineering

Introduction

Assessment of the functionality of engineered cartilage is hampered by the lack of correlation between mechanical properties and tissue constituents. Molecular organization and crosslinks play a role, but it has also been proposed that functionality arises when contact occurs between zones of matrix associated with individual cells [1,2], see Fig. 1,2.

Objective:

Determine whether the microscopic distribution of newly synthesized matrix contributes to the development of the functional properties of tissue engineered cartilage.

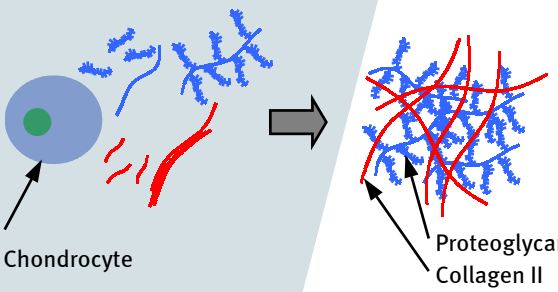

Figure 1 *Extracellular matrix components, synthesized by chondrocytes, undergo an assembly process to from a mechanically functional extracellular matrix.*

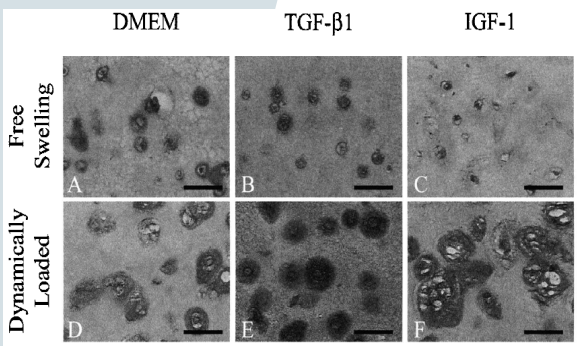

Figure 2 *Example experimental matrix distribution [1]. Cells embedded in an agarose hydrogel stained for proteoglycans at 28 days. Matrix deposition proceeds outwards from the cells.*

Methods

A finite element approach, based on a representative part of the microstructure, was adopted, see Fig. 3. Matrix synthesis, diffusion, binding and degradation were described [3]. Local stiffness and permeability were taken dependent on the bound matrix concentration. Subsequently global tissue properties were derived [4].

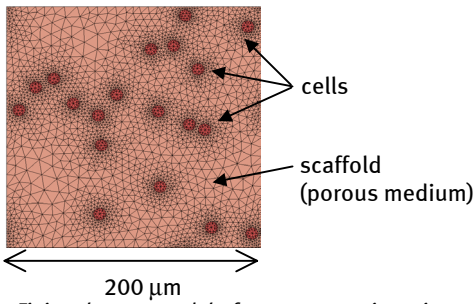

Figure 3 *Finite element model of a representative microstructure. Periodical boundary conditions were applied.*

Results

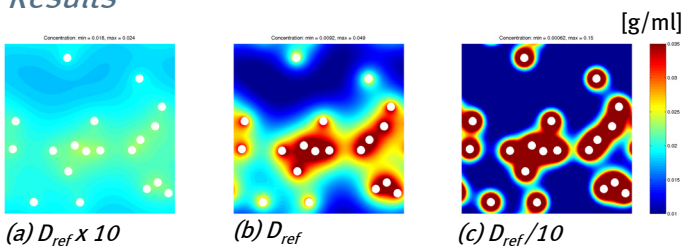

Figure 4 *Computed matrix distribution for different diffusion coefficents, ranging from homogeneous (a) to very localized (c).*

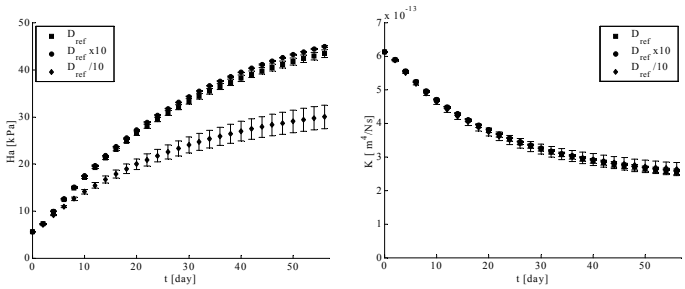

Figure 5 *Resulting aggregate modulus Ha and permeability K over time. Averaged over 5 different microstructures in two directions.*

Conclusions

Overall stiffness and permeability are to a large extent insensitive to the local matrix distribution. Results underline the need for caution in interpreting functionality from histology and the importance of complementary measurements of intrinsic matrix organization.

References:

[1] *Mauck RL, 2003, Tissue Engineering, 9(4), pp. 597-611.*
[2] *Quinn TM, 2002, Biorheology, 39, pp. 27-37.*
[3] *Dimicco MA, 2003, J. Orthop. Res., 20, pp. 842-848.*
[4] *Breuls RGM, 2002, J. Biomech. Engi., 124, pp. 198-207.*