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Published: 01/01/2004

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Link to publication

Citation for published version (APA):
Structural properties of natural porcine aortic valves

A. Balguid, C.V.C. Bouten, F.P.T. Baaijens
Eindhoven University of Technology, Department of Biomedical Engineering

Introduction
Currently, tissue engineered (TE) heart valves are not sufficiently strong to function as aortic valves. The future design of TE aortic valves will be based on the native human aortic valve, with regard to mechanical properties, structural and biochemical composition of collagen in the valve. In this study porcine valves are used to develop standardized methods to assess these specific features.

Materials and Methods
Biochemical assays
The homogeneity of collagen distribution throughout a porcine aortic leaflet was analyzed on a local scale. In an HPLC analysis, collagen was represented by the amount of hydroxyproline (Hyp), collagen cross-links were measured with hydroxypyridinium (HP).

Fibril thickness
Former studies [1] have suggested that tissue subject to high stresses result in thinner collagen fibrils and higher fibril density. This theory is analyzed using i) a numerical model [2], which predicts stresses in the aortic leaflet (fig. 1) and ii) transmission electron microscopy (TEM) photos of high and low stress areas in the leaflet. Ellipses were fitted on the fibrils in the photos to estimate the diameter.

Results and Discussion
Biochemical assays
Fig. 2 shows a colormap of the collagen content in the three porcine leaflets.

The average collagen content in porcine valves is about 80% of human collagen values from literature [3]. Student t-tests (\(\alpha=0.05\)) show significantly higher collagen contents in the mid region (inner 8 segments) of the leaflet compared to the outer region (outer segments)(fig. 3).

Fibril thickness
Fig. 4 shows the collagen fibrils in the high and low stress areas of the leaflet.

A slightly larger fibril diameter seems to be present in low stress areas compared to high stress areas. This corresponds with former studies [1]. However, this is not statistically proven and more experiments are needed to draw meaningful conclusions.

Future Research
The proposed methods and mechanical testing will be used for tissue engineered and native human valves on a larger scale to provide more information. Furthermore, the effect of age on the features will also be examined.

References: