Spatial and temporal mapping of native auricular elastic cartilage

Author(s):
Nimeskern, Luc; Rotter, Nicole; Müller, Ralph; Stok, Kathryn S.

Publication Date:
2012

Permanent Link:

https://doi.org/10.3929/ethz-a-007563461 →

SPATIAL AND TEMPORAL MAPPING OF NATIVE AURICULAR ELASTIC CARTILAGE

Luc Nimeskern (1), Nicole Rotter (2), Ralph Müller (1), Kathryn S. Stok (1)

1. Institute for Biomechanics, ETH Zürich, Switzerland; 2. Department of Otorhinolaryngology, Ulm University Medical Center, Ulm, Germany

Introduction

Auricular cartilage is responsible for the shape stability of the auricle, i.e. outer ear, while allowing for large deformation (sleeping, wearing helmets, etc). In the field of reconstructive surgery, tissue-engineering (TE) is a promising approach to repair injured auricular cartilage. To be functional, it should mimic the mechanical properties of the native tissue. Therefore, a precise mechanical characterization is required to provide a benchmark for assessment of auricular TE outcomes. Three types of cartilage have been defined: hyaline, elastic and fibrocartilage. Auricles are classified as elastic; and whereas hyaline and fibrocartilage have been extensively characterized, only little data are available for elastic cartilage. This study aims to characterize mechanical properties of human auricular cartilage and compare them to hyaline cartilage from the ribs and nose.

Materials and Methods

Fresh human auricular cartilage samples were harvested during reconstructive surgery (n = 39) or post-mortem (n = 42) with approval of the local ethics committee. The harvesting location (tragus, concha, helix/antihelix) was recorded. Additionally, rib (n = 28) and nasoseptal cartilage (n = 15) were harvested during repair surgery. Samples were cut to 5x5 mm^2, and tested in stress-relaxation (5%-strain steps, 20 minutes relaxation time) on a Zwick-Z005 machine (10 N load cell, Ø0.35 mm indenter). Equilibrium modulus, E_{eq}, was computed.

Results

Figure 1a shows E_{eq} for rib (E_{eq} = 20.0 ± 14.7 MPa) and septal cartilage (E_{eq} = 12.1 ± 11.1 MPa) was significantly higher than for auricular cartilage (E_{eq} = 2.70 ± 1.50 MPa). Auricular cartilage E_{eq} was significantly lower in the tragus than other regions, fig 1b. No significant correlation was observed, r^2 = 0.01, between E_{eq} and donor age, fig 1c.

Discussion

Cartilage from the ribs and nose is significantly stiffer than cartilage from the auricle, which can be explained by the higher elastin content in elastic cartilage compared to hyaline cartilage. Elastin is a highly resilient protein which has an important functional role, e.g. in skin or elastic arteries. Surprisingly the mechanical properties of auricular cartilage do not correlate with patient age. Elastin is known to degrade over time; therefore mechanical properties were expected to decrease with age - which was not the case. Mechanical differences observed regionally in the auricle may be explained by spatial variation in biochemical composition. However, there are no reports in literature of spatial changes in the composition of auricular cartilage. The study will be extended to include a larger number of samples in order to address these points.

Conclusions

In this study, we demonstrated that elastic and hyaline cartilage have significantly different mechanical properties. Additionally, mechanics of elastic cartilage, relevant for TE, were measured. These values will be used as a benchmark to assess the outcome of auricular cartilage TE procedures.

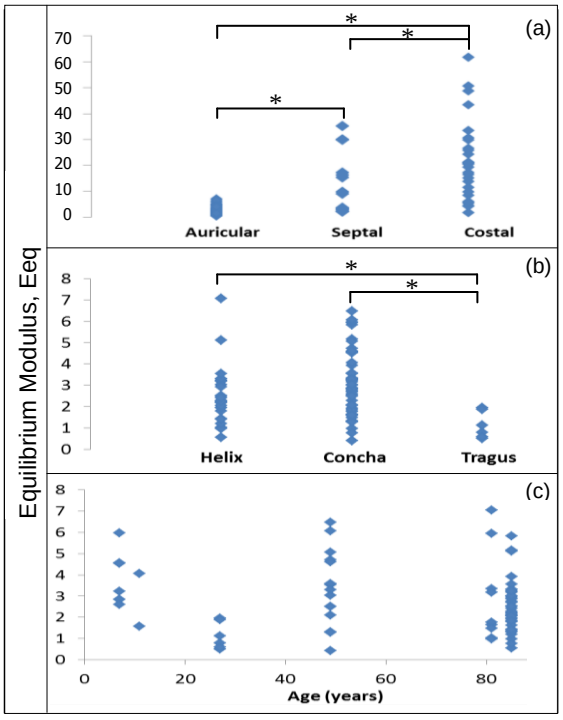

Figure 1: Equilibrium modulus (a) of auricular cartilage compared to septal and costal cartilage, (b) of various locations within the auricle, and (c) plotted against donor age. (*) indicates significant difference, $p < 0.05$.

Acknowledgements

SNSF (NRP63) and ERA-NET/EuroNanoMed (EAREG-406340-131009/1).