Author's title and name: Mgr. David Vondrášek
Institution: Charles University in Prague
Faculty of Physical Education and Sport
José Martího 269/31
Praha 6, 162 52, Česká republika

Study programme: Biomechanics

Thesis name: Morphological and mechanical properties of fibrous tissue localized in congenital talipes equinovarus

Thesis supervisor: Ing. Mgr. Daniel Hadraba, Ph.D.

Year of defense: 2024

Number of pages: Total 111; Cover 1, Declaration 1, Acknowledgment 1, Preface 2, Table of content 2, Main text 77, Bibliography 27

Number of scientific papers: 6 papers

Key words: *talipes equinovarus* congenitus, relapsed clubfoot, label-free optical microscopy, atomic force microscopy, mechanical properties, multi-modal analysis

Text: Abstract (english)

Abstract

Talipes equinovarus congenitus (clubfoot) is a congenital deformity affecting lower limbs, mainly the areas around the ankle joint and foot. The affected feet have a distinct club-like appearance, where the feet are contracted to the medial side. The medial side contains fibrotic tissue, which contains an increased amount of collagen deposited by cells through fibrosis. As a result, the tissue of the medial side appears as stiff to orthopaedic practitioners, and clubfoot is frequently reported as contracted and stiff in the literature without any quantification of the mechanical properties. Several scientific papers address the extracellular matrix of the clubfoot tissue and characterize the protein composition and relations between the proteins. In engineering, an increase in the amount of building material results in an increased stiffness, but so does a change in the structure and properties of the building material. Therefore, the thesis aims to quantify the morphological and mechanical properties of the relapsed clubfoot tissue obtained from surgical corrections of the deformity. The tissue biopsies are extracted from the medial and lateral sides of the deformed foot. The lateral side tissue acts as a relative comparison to medial side tissue, comes from the limb affected by the same deformity, functions as an antagonist from the biomechanical perspective and orthopaedic practitioners refer to both medial and lateral side when concluding on the characteristics of the relapsed clubfoot tissue. The morphological and mechanical properties of the tissue biopsies are investigated through methods of correlative microscopy and multimodal analysis. Label-free optical microscopy and atomic force microscopy revealed that the medial side contains more collagen ($p = 0.035$), less adipose tissue ($p = 0.037$) and has a higher Young's modulus (stated as a median, interquartile range: E_{med} = 186 kPa, 90 – 458 kPa; and E_{lat} = 130 kPa, 62 – 350 kPa). Additionally, the collagen fibres of the medial side propagate at a higher frequency of the crimp pattern (eccentricity $\varepsilon = 0.61 \pm 0.16$) than in the lateral side ($\varepsilon = 0.48 \pm 0.18$ [-]). The results suggest that the increased stiffness in the medial side tissue reported by orthopaedic practitioners and surgeons has another cause besides fibrosis. The results indicate that a different micro-structural organization exists between the tissue of the medial and lateral sides of the relapsed clubfoot. The thesis

offers a multi-correlative approach that thoroughly investigates the relapsed clubfoot tissue.