OPTICAL COHERENCE TOMOGRAPHY (OCT) ASSOCIATED WITH CLEARING TECHNIQUE FOR MEASURING THE EVOLUTION AND DEGENERATION OF SKELETAL MUSCLE OPTICAL PARAMETERS

Juan Felipe Escobar H (1,2), Stephane Avril (3), Diego Alexander Garzon (2), Olfa Trabelsi (2)

1. Numerical Methods and Modeling Research Group (GNUM), Universidad Nacional de Colombia, Bogotá, Colombia; 2. Université de technologie de Compiègne, CNRS, Biomechanics and Bioengineering, Compiègne Cedex, France, Country; 3. Mines Saint-Etienne, Univ Jean Monnet Saint-Etienne, Inserm, U 1059 Sainbiose, F-42023 Saint-Etienne, France

Introduction

In 2002, diseases related to the osteo-articular system and muscles accounted for 7.1% of French social security expenditures, without taking into account neuromuscular diseases[1]. The aim of this research is to understand muscular degeneration whose physiopathology has not been precisely described (such as Duchenne's disease), to discover new therapeutic targets and to increase the chances of developing effective therapies. Duchenne Muscular Dystrophy (DMD) is the second most common monogenic disorder in Western countries. To date, no treatment exists to curb this disease [2, 3,4].

This work focuses on exploring the microstructure optical changes between physiological and DMD rat muscle. Several blind Image Quality metrics are used to estimate the degeneration of the muscle. Contrast per Pixel (CPP) and three different No Reference Image Quality (NR-IMQ) metrics were used to estimate the quality of OCT images: Perception base Image Quality Evaluator (PIQE), Naturalness Image Quality Evaluator (NIQE) and Blind/Reference less Image Spatial Quality Evaluator (BRISQUE). Histological measurements are compared to OCT image metrics.

Methods

Optical Coherence Tomography (OCT) imaging

To assess the three-dimensional microstructure architecture of the sample. An OCT system (Thorlabs OCT-TEL220C1) with a wavelength of 1.300nm, a focal length of 18 mm and a maximum sensitivity range of 111dB was used. Before OCT imaging, samples were immersed in a PG in PBS for one hour, then fixed in a PG solution [5]. Finally, after finishing the imaging process, the sample is conserved again in PBS.

Muscle isolation

Wistar rats, were used in this study. The animals were housed in standard cages under controlled conditions of temperature and lighting. The protocol used in the present study complies with the principles of animal care and the French ethical rules of veterinary authorities, according with the "European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific Purposes" (Council of Europe No. 123, Strasbourg 1985). Contrast per Pixel (CPP) and three different No Reference Image Quality (NR-IMQ) metrics were used to estimate and compare the quality of OCT and histological images.

Results

Increase of homogeneous refractive index across the muscle and reduction of the scattering coefficient were induced by PG. This leads to an increasing transparency of tendons and muscle in visible light domain as shown in Figure 1 a, b. The transparency, also increased in the near infrared light spectrum, significantly improves OCT acquisition in terms of contrast and measurement depth. It can be seen in figure 1 that images obtain from OCT are similar to those obtain in a histology. Additionally, disintegration of muscle fibers and absence of muscle bundles unit is notable in pathological muscles.

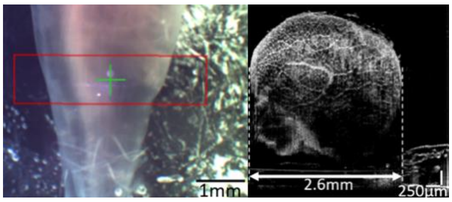

Figure 1: muscle immersion in 1 hour of PG. It can be seen the effect of PG as clearing agent.

Discussion

The application of new techniques like, OCT imaging enables to visualize and quantify the microscopic architecture of the muscle without destroying it, which gives the possibility to preserve the sample for further uses such as mechanical testing or molecular characterization. To assess the use of OCT imaging, with PG tissue clearance, morphological and mechanical analysis are going to be carried out. Using PG solution as a hyperosmotic solution exacerbated chemoelastic effects.

At this moment further analysis are being developed to characterize the image method. Also, to conclude more application that could be performed using the same method.

References

1. V. Mournetas, et. al. The notebooks of myology, 17: 49-50, 2018.
2. Société Française De Neuropédiatrie Protocole National de Diagnostic et de Soins (PNDS), 2019.
3. V. Mournetas, et al. Les cahiers de myologie, 2018.
4. A. E. H. Emery, et al. Oxford University Press. 2015. ISBN 978-0-19968148-8 (2020).
5. V. A. Acosta Santamaría, et al. Frontiers in Mechanical Engineering, 2018.