MR texture analysis of regenerating mouse muscle at 7T: an in-vivo study

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INTRODUCTION

The mdx mouse is a model of human muscular dystrophy characterized by a genetic deficiency for dystrophin which leads to numerous spontaneous muscle fibers degeneration-regeneration cycles which are difficult to interpret. A mouse model of muscle injury (with injection of notexin) involving a single well-defined cycle of degeneration-regeneration was studied to distinguish between these two processes, using both MRI texture analysis and histological data. More precisely the aim of this study was to a) monitor the muscle degeneration-regeneration process and b) to define more precisely the local variations of the muscle texture after notexin injection .

MATERIAL AND METHODS

21 mice were used in this study. Muscle *Tibialis Anterior* (TA) injury was produced by injecting notexin . Spin Echo T2-weighted MR Images of axial muscle sections were then performed on the whole leg throughout 13 days after notexin injection on a horizontal 7T magnet (Oxford, UK). With texture analysis method several parameters are available to characterize each ROI by a set of 204 texture parameters. Correspondence Factorial Analysis (CFA) was performed to make discriminations between those texture profiles. The evolution of the injected muscle was also studied in time course for all animals with Hierarchical Ascending Classification (HAC) of the profiles. The animals were then sacrificed and the whole leg was removed for histological examination by hematoxylin-eosin staining.

RESULTS

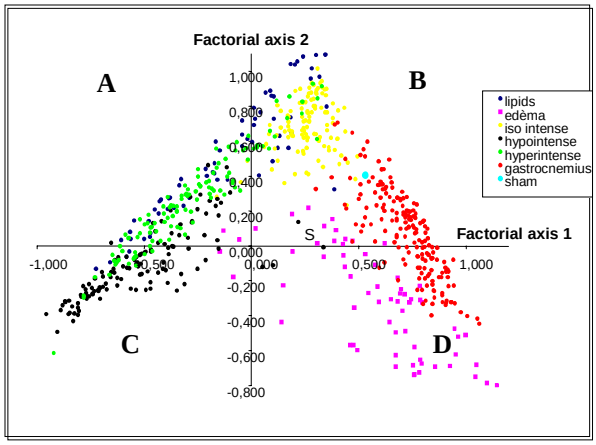

Fig. 1 : CFA showing the discrimination between the different ROI selected on the mouse leg MR images from day 0 to day 13.

* The six ROI types are represented as clusters of different colors on **fig.1.** i) Part A consists mainly of hyper-intense areas and fat, part B mainly of the sham, gastrocnemius and iso-intense areas, part C hypo-intense areas, and part D edema. ii) The texture of the three different ROI types (hypo-, hyper-, and iso-intense) selected in the injected muscle did not correspond to either healthy tissue (GA) or edema.

* The follow up of the ROI corresponding to total axial slice of the leg is represented by a dendrogram on **fig.2**. Two main classes, C I and C II, can be distinguished, and correspond to the texture of the leg on day 0 and between days 1 and 13, respectively. CII can then be subdivided into two classes (C IIa and C IIb), on the basis of differences between the texture on days 1 to 5, and that after day 6.

* Notexin injection rapidly caused infiltration of the muscle by inflammatory cells. On day 1, many of the myofibers in the notexin-injected muscles displayed histological features indicating degeneration and necrosis (**fig. 3b**). On days 2 and 3, the myoblasts proliferated and differentiated (**fig. 3c**). By day 3, the first myotubes had appeared. The fusion of the myoblasts was very marked from day 4 (**fig. 3d**) to day 7 and persisted up to day 9.

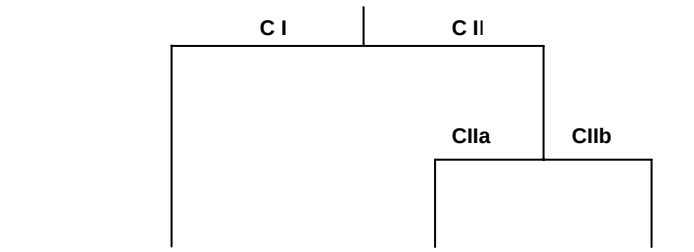

Fig. 2 : HAC showing the different time courses of the ROI texture profile of *tibialis anterior* muscle.

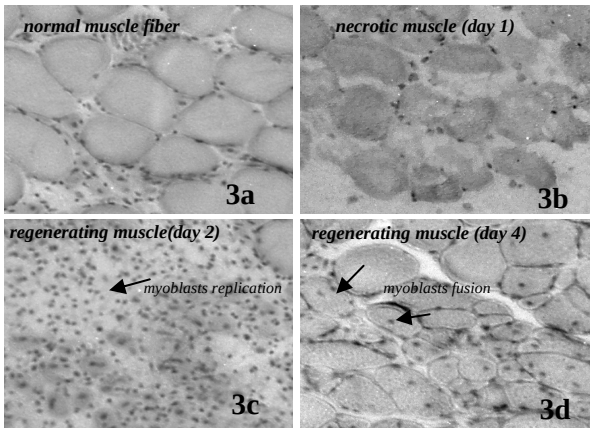

Fig. 3 : Hematoxylin/eosin-stained cross section of frozen tissue.

CONCLUSION

Our study confirms that several different stages can be distinguished during the regeneration, process. This means that MR image texture analysis seems to offer a non-invasive alternative to histological examination and also generates some quantitative parameters. Texture analysis of MR images looks promising for potential use with other muscle injury models, in particular the *mdx* model, in which several degeneration-regeneration cycles occur simultaneously.