Influence of Post Diffusion Tensor Image Processing on FA Measure of Myocardial Infarction in Porcine Model

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Introduction

Investigation of contrast and clinical parameter values in diffusion tensor magnetic resonance imaging (DTI) of infarcted heart helps to better understand the functional adaption and remodeling process. However, it is difficult to characterize cardiac pathology with clinical parameters such as fractional anisotropy (FA) since it highly depends on image post-processing. As cardiac DTI suffers from low resolution, interpolation of the tensor fields typically is performed to improve the image resolution. Several tensor interpolation techniques have been reported[1-3] and studies have been performed to compare the effects of such techniques in the tensors quality[4] and diffusion indices behavior[3]. Most existing interpolation techniques may introduce FA decrease during interpolation, misleading the interpretation of the obtained results since FA decrease also exists in myocardial infarction region. Despite this, no study has been done to understand the effects on FA of diffusion tensor interpolation in the presence of myocardial infarction and how this can affect clinical interpretation. The purpose of this study is to investigate the FA alteration after myocardial infarction and to get insights into possible influences of interpolation methods on FA measure, so that researchers or cardiologists needn't duplicate these efforts when performing post image processing in DTI.

Materials and Methods

Fifteen pig ex-vivo hearts were acquired on a Siemens Avanto 1.5T MR Scanner. An example of porcine T1-weighted MR image is shown in Fig. 1, where the zone marked by the red contour corresponds to the core of an acute myocardial infarction in the left anterior descending (LAD) territory and the blue zone indicates a remote region. To interpolate the tensor fields from the cardiac DTI, a number of interpolation techniques were used: classical Euclidean interpolation, Cholesky interpolation[1], Log-Euclidean interpolation[2] and tensor feature-based interpolation[3]. FA value variations between the infarction region and remote region before and after interpolations have been compared.

Results

The variation in FA values between infarction region and remote region, and the influence of interpolation methods on FA values are illustrated in Table 1. The FA value decreases significantly (18.7%) in the infarction region compared with values in the remote region. We can also see that the Euclidean, Log-Euclidean and Cholesky interpolation methods introduce significant decrease of FA values ("FA collapse") and that the bigger the interpolation factor is, the larger the FA collapse from the three methods. It should also be noticed that when the interpolation factor is 8, the decrease introduced by interpolation in the remote region can even reach 15.2% which is very close to the FA values of the original infarction region. In this sense, one cannot distinguish the infarction and remote regions using an absolute threshold which is observed from the original FA maps. In addition, the difference between infarction and remote regions has been narrowed using Euclidean and Cholesky methods, and this phenomenon has been exacerbated when the interpolation factor grows. When the interpolation factor equals 2, the difference between infarction and remote regions has been enlarged using Log-Euclidean and feature-based interpolations. When the interpolation factor is 8, the difference is also narrowed but close to that from the original tensor fields.

Discussion

The fact that existing tensor interpolation methods such as classical Euclidean, Cholesky and Log-Euclidean interpolations induce FA collapse implies that, between two anisotropic tensors with close FA values but with different orientations, these methods may produce an almost isotropic tensor (a sphere). The collapse effect of the FA causes the FA values in abnormal myocardial zone before interpolation to be rather close to the FA values in the adjacent normal zone after interpolation. That may cause confusion when using the FA as absolute reference for assessing the difference between normal and abnormal zones. As indicated in [5,6], there is a negative correlation between degree of anisotropy and fiber disarray. The collapse effect of the FA could then introduce fiber disarray, because these existing methods pay attention to tensor shape, and ignore tensor orientation. In this sense, the feature-based interpolation method will yield better fiber tracking. When the interpolation factor is big, interpolation methods lead to different levels of decrease on the difference between infarction and remote regions.

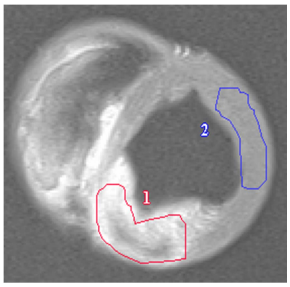

Fig. 1 T1-weighted ex-vivo post-gadolinium image

Table 1 Influence of diffusion tensor interpolations on FA values. Interpolation factor equaling 2 means a new tensor is interpolated between two tensors. Diff indicates the FA value difference between the remote region and infarction region. Inf. and Rem. respectively indicate the infarction region and remote region.

	Interpolation factor = 2			Interpolation factor=8		
	Inf.	Rem.	Diff	Inf.	Rem.	Diff
Original	**0.3359**	**0.4133**	**0.0774**	**0.3359**	**0.4133**	**0.0774**
Euclidean	0.3162	0.3844	**0.0682**	0.3002	0.3524	**0.0522**
Cholesky	0.3208	0.3952	**0.0744**	0.3058	0.3684	**0.0626**
Log-Euclidean	0.3227	0.4058	**0.0831**	0.3084	0.3832	**0.0749**
Feature	0.3367	0.4157	**0.0790**	0.3255	0.3984	**0.0729**

Conclusion

This work suggests that precaution should be taken with diffusion tensor interpolations when using absolute indexes (e.g. FA value or difference of FA values) to distinguish infarction and remote regions, since interpolation methods may affect FA values in a non-negligible manner. In addition, since FA decrease is related to fiber disarray, attention should be paid on interpolation method selection when performing subsequent processing and analysis, e.g. fiber tracking.

Reference

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