INTRODUCTION: After stroke, brain tissue undergoes time dependent heterogeneous histopathological change. These tissue alterations have magnetic resonance imaging (MRI) characteristics, which allow segmentation of ischemic from nonischemic tissue. MRI segmentation generates different zones within the lesion that may reflect heterogeneity of tissue damage. Objective computerized multiparameter MRI has not been employed to identify and classify ischemic cell damage. This study presents a novel model of tissue characterization based upon the angular separation of tissue clusters in feature space. This model and an unsupervised computer segmentation algorithm implementing a modified version of the Iterative Self-Organizing Data Analysis Technique (ISODATA) are utilized [1]. We test the utility of this model to characterize ischemic tissue after permanent middle cerebral artery occlusion in rat. Multiparameter ISODATA measurements of ischemic tissue damage were compared to quantitative histological characterization of the tissue from 4h to 1 week after stroke.

METHODS: MRI was performed on rats (n=20) subjected to permanent middle cerebral artery occlusion. Diffusion-weighted (DWI), T2- (T2WI) and T1- (inversion recovery) weighted coronal images were acquired at 7 T. MRI were obtained acutely (4-16 hr, n=6), subacutely (16-24 hr, n=8), and chronically (48-168 hr, n=6) after stroke on separate groups of animals. After imaging, hematoxylin and eosin stained brain sections were obtained for histopathological analysis. ADC Maps were created using Eigentool Image Analysis software [2-3] The MRI were coregistered and warped to histopathological sections [4]. MRI lesion areas were defined using DWI, ADC maps, T2WI, and ISODATA. ISODATA clusters were tested for similarity and classified as normal or abnormal. Classifications of clusters were determined by the angle between clusters [5]. The abnormal tissue clusters determined from similarity measures were overlaid onto histopathological sections for microscopic evaluation [6]. Each tissue region was scored from zero (no neuronal damage) to ten (severe damage) by a neuropathologist (ZGG, AVG). These tissue regions and corresponding angle between the normal and abnormal were correlated to the histologically defined score.

RESULTS: The angle model utilized to characterize tissue is shown in figure 1. The abnormal ISODATA tissue clusters overlaid onto the histological section exhibited morphological ischemic cell damage ranging from acute ischemic neuronal changes to pan necrosis. ISODATA clearly discriminated between ischemic morphological altered tissue and morphologically intact tissue. We demonstrate that the ISODATA segmentation of tissue identifies a gradation of cerebral tissue damage at all time points. The histological scoring of ischemic tissue from 4 h to 1 week post stroke on all the animals were significantly correlated (r=0.78, p<0.01, n=20) when using a multiparameter (T2, T1, DWI) ISODATA segmentation (Table 1).

CONCLUSIONS: We have demonstrated that integration of multiparameter MRI data in the ISODATA angle can distinguish potentially salvageable ischemic tissue from tissue that is irreversibly damaged.

REFERENCES: