So, MRI is a capable measure of the _____ water displacements in the TCO. That's not actually all the reason we interest in the diffusion of water diffusion in the TCO. When we measured of diffusion coefficient in the TCO and also the very sensitive of the micro-environment and that makes actually of this type of measurement. It is interesting, but of course also made of a interpretation of data quite complicated. So, on the, also right now in the legislature on the ready of a many of examples demonstrate a diffusion MRI is of a quite valuable to for of a diagnosis of the Q stroke, also there is of a increasing of literature in, to shield of a diffusion MRI higher potential predict of a treatment responses to the tumor. Definite later on I will show some beautiful pictures of diffusing tensor MRI, definitely will play important role for us understand of the

functional activity in the brain. So, if you have a bottle of water of water molecules are able to move around pretty freely and in this case you roughly have diffusion coefficient around three of ten to the minor three mm square by second. However, you bring water molecules move somewhat freely and have encountered cell structures from time to time. So, that's why it is of the diffusion in the TCO quite sensitive to the local structure. On here, I tried to use the _____ is loose straight little bit of the sting of the structure in the brain; one is the gray matter, one is the white matter. In the gray matter you have a water molecule diffused in the extra cellular or extra cellular space, but also water can cross the membrane of the cellular membrane. In the white matter is slightly different and some structure is sorta like a sausage, a little bit cylindrical and is surrounded also by other

type of mylan layers and they actually make the diffusion across the membrane is almost completely restricted. So, this type of diffusion we call restricted diffusion. So, if the cellular structure definitely will decrease of your measure apparent diffusion coefficient. Also makes the diffusion anastrophic and the apparent diffusion coefficient can be affected by many different factors. For instance, cell density and the membranes permeability to the water and sensitivity to water counts ____ therapy between the intra or extra cellular space and even the geometric changings of the cells also can effect the diffusion coefficient and actually also perhaps metabolism of the cells also have impact on the, your measure diffusion coefficient. By request I actually show you some simple sketches of the past sequence. On the top line, show you if you apply the ninety-degree

and one degree of _____ and you wait a little time, you can get _____. How we gonna measure diffusion of the water molecules? You need to apply a pair of diffusion gradients and 1% on another one that follows the 180-degree pass. And for the first upgrading pass we will diffuse the MR signals. On the second upgrading pass are able to refocus diffusing if the molecule is not move around. And overall, the two gradients together will attenuate your MR signal for mobile water molecules. In the free water situation you will have some exponential decay of signals. They'll say exponential decay all depends on the two major parameters; it obviously depends on the size of diffusion coefficient. Also depends on another parameters. We call B volumes, you can manipulate B volume, it depends on the magnitude of the grading and the duration of the

grading and also of time interval between the two gradings. Here, I'll show you some examples. Of the first image is of what we call a B0 imagings. Here you didn't apply additional diffusion encoding so you get pretty much of a T2 wave images. The next thing, you apply the diffusion encoding and in this case the B volume is of 1000 and you can see a signal intensity definitely of attenuated and also the decreasing of the signal depends on the size of the diffusion coefficient and why it's the obvious place you look at of the _____ and ventricle is very dark because there's primarily is the flu and have a large diffusion coefficients. From there, if you have a single eventual decay and also if the diffusion isotropic and you can use the simple two measurements determining your

apparent diffusion coefficient. One is the easier way to do, you do B=0 and you do another diffusion your coding and B is greater than zero, you do the simple exponential fading. You can compute ABC and you can see in the ABC maps and again is CF, F is very bright and they're very little contrasted between the gray matter and the white matter. And however, you also can use B volume a little bit higher than the most people using, 1000. And when you increase the B volumes and you can see the contrast between the gray matter and the white matter is reversed. And in the lower B volumes you pretty much have a contrast similar to weighted imaging while you increase the B volume to about 3000^{th} and the white matter becomes a little bit brighter than gray matter and this can be explained by single figures and at B=0 on the signal intensity motor reflector of

weighted imaging signals of the brightest one is CSF, dark one is of white matter and we also know it's the CSF has a larger diffusion coefficient, so therefore the curve attenuates faster than the others and when you apply the data with B=2000 and the differences stagger but between the white matter and the gray matter you pretty much have a similar contrast like T2 weighted imaging. When you increase the B volume to here about 3000 and is of the contrast between the white matter and gray matter reversed. So, people start questioning is that really truly of the decay of attenuation of the signal in the TCO it truly really of one exponential or something else. You can actually evaluate this allowing as I spend time looking to this. This is part of a lock of the signal versus the B volumes for the free water pretty much you got a straight line that's an indicator of manual

exponential pretty much to describe the situation. When you look at many different ROI's in the white matter or gray matter, those curves start at the part of the straight line, free water diffusion lines. So, first shot you're thinking, ok, now that the exponential where I can try to fade away the bike exponential of a curve. Here, you have a three of independent of variables and the 2D fusion coefficient; one is the fast, one is the slow. And also you have of a fraction volume for one of them. Other one will be related to. So, here is, some of the results on the more or less people got similar results. Yes, definitely you can ____ two distinguished ABC volumes. However, the fraction volume of the fast diffusion coefficients have a quite large fraction volume, roughly around 70% and this is something not matching with what we know about fraction volume for actual on the

intracellular water space. So, in other words the model may give you a good fit but now may be a really explain the true underline of what's going on. So, next let's get anatrophic diffusion. I mentioned at the beginning the cellular structure also actually

make especially in the white matter and the diffusion will be, depends on the directions and is definitely a lot of, in the white matter, larger diffusion is along the fiber track and in the direction perpendicular to the fiber track, definitely more restricted. In the gray matter you may also have a small anastrophy. So on the, we can use _____ and geometrically describe the situation and the three other major access of the ____ represents three of the principle diffusivities and the orientation of the _____ also can be described using the three independent parameters. Mathematically this can be described

by three by three symmetric metrics and also called a tensor and you have six independent elements, three diagonal, three off diagonal elements. So, in this case, diffusion encoding will become duration and dependent. So, in order to determine the diffusion tensor you need at least seven regimens. One is B=0 to determine the magnitude of the signal and you need at least six noncolinear of diffusion coding to determine the diffusion tensor. So, if you look at some, the equation will be from that by this and D is the diffusion tensor and the Q actually here is the unix factor describing the direction of the encoding. Here, I'll show you some examples and this is the B=0 images _____ weighted images and the other is six diffusion encoded images and you probably feel very difficult to understand the property of the TCO, use those kind of images. So,

use the _____you can determine the other six diffusion tensor elements that have three diagonal elements and they have a much larger diffusion coefficient and the bottom three diagonal elements and from there most people further manipulate doing mathematics, mind you, but by manipulation you can diagonalize your diffusion tensor to obtain three _____ volume. This is three _____ volume quite meaningful and representatives of those three principles of diffusitivities in the _____ and ____ the orientation of the _____. I like to draw your attention to the first item _____. There's already have several paper demonstrated the orientation of the fiber ____ well represented by the first _____. From there actually one is last and very fast _____ field is going on there, try the tracking the first _____ to represent your fiber orientation fiber connection. So, any way you already

have many, many parameters for the diffusion tensor but in most cases up to most use indexes is represented by this too. One is describing the average of the diffusion coefficient either by the sum of the three _____ or either the average of the three ____. So you can see in here is a very distinguished any difference between the gray matter and the white matter and another index we use in the high frequencies in relative anastrophy and this you can actually see a huge difference, a dramatic difference between the white matter and the gray matter. So, in this RA index and the theory represented isotropic diffusion and when the RA reached the maximum and that indicated diffusion is one-dimensional. In other words, the two-dimensional complete restricted and in this case for the largely of the fibers is a higher anastrophic diffusion and this is always bright on the

RA imaging. Also, on the white matter fiber orientation can be illustrated and attracted by the first _____. Here is just the simple color representing gray color indicating the fiber is perpendicular to the plane and red color indicating fiber is in the plane and the orange color indicating some oblique fiber. So, I will show you some obliquations of diffusion imaging. Right now it's in diffusion imaging is one of the very valuable

diagnostics to the Q stroke and for the Q stroke ABC will be decreased and so this is the one of the cases. However, for the chronicle stroke because your TCO becomes necrotic, so you have a high ABC. So, one single image modality can actually also distinguish the O stroke and of the Q stroke and also now is there is always heterogeneity in the of a stroke lesions and you can see on this ABC map and just have the information maybe

provide information for the prognosis of the recovery. Also I already attached, mentioned a little bit and the stroke lesion actually evolved over time and ABC also evolved over time. This is the one case _____ after one sided stroke you barely see any decrease of ABC and three days later you see massive decrease on the ABC and three months later you see elevated ABC on the posterior part is less elevated. Also is start, when the patient, stroke patient administrated to the hospital the difficult, no definite onset of the stroke. So, they tried to determine onset if the stroke was one of the big deal. So, when you look at this as two patients. One day they had the first MR scan of the stroke, the ABC or ADO decrease and the, but however the T2 images of one is almost no change, another one is a show of increase. But when you look at with anastrophic

diffusion, one has increase anastrophic diffusion, one is not. So, this showed up negative correlation between anastrophic diffusion and the T2, the _____ also provided additional information to actually understand onset of the true onset of the stroke. Next, I'd like to show some example in the tumor and here I show a signal intensity of a attenuation curve from the tumor and from necrotic _____ and the one you at is the curve from the tumor and very carefully it definitely looks like is a ____ of a _____. So a lot of people try to understand what the relationship of attenuation curve versus zero density. In one of the biological samples you can actually do some simple experiments like this. Here, you plot loud signal versus B volumes. You don't pack any cells, you get on a straight line indicating the diffusion of the water pretty much freely and when you start packing cells

the curve will start bending and definitely against the part that formed a single exponential and if you, it is very reasonable _____ you want to _____ exponential curve for the F1, the D1 is the fraction volume on the diffusion coefficient for the fast diffusion and that the _____ of the parameter of decreasing with increasing of the cellular density. However, for the D2 the diffusion for the slow upper diffusion rarely changes. This will give us some indication of a high diffusion depends on the cellular densities. When you look at the cooling _____ it's a little bit more complicated and this is the end of the curve and here a plot histogram of the ABC and the sign curve is from a ventricle and is many _____ of the peak is at around 3000of ten to the minus six, is pretty much like free water when you look at white matter of yellow colors and the number in general

below the 1000 suggests a virus cellular. However, when you look at the tumor and the tumor is on the T2 image you see some edema and if you put _____ around here you have edema is the peak around here and when you look at a pair of a tumor with a little edema on the signals it's almost a coincidence with normal white matter. So, in the tumor in general you get a number somewhere between there. It depends on many situations and here is the one case for Tommy Shen paper. They demonstrate before RT treatment. You have diffusion coefficient is around 1.6 on the over the treatment of the

tumor volume shrinks, but ABC also increased. That's why in the imaging of ten at the end of RT treatment you see ABC is elevated. However, in most of clinical cases you may not be seeing that kind of clean cut. Mostly you would see a lot of heterogeneity on

the presumably also is partially responds to the RT. This is one example here. I plotted a histogram of ABC in the tumor volume. This represented before the RT and after 30 Gray, six weeks after completion of the RT and six months after RT. So you see part of the voxel in part of the tumor definitely have elevated ABC and usually this occur and you can map this back to your imaging. Look at where is the voxel have elevated ABC, where is ABC remains unchanged. Another actually published a paper also looking for early indicators for therapy response and the data actually collected B volume is not just used to B volumes, but collected 14 B volumes up to 3600. So on the two way you do it. One-way is the conventional way, you ____ with the single exponential you obtained the other conventional ABC. Another way, you can ____ with the bi-exponential curve, you

obtain three of the parameters, also you can explore the ratio among the three parameters, which one is more sensitive. So, on the theory results suggests actually the conventional ABC's are less sensitive and not as good as the indicator for use of something here to use the ratio of the farther diffusion and over the fraction volume of low diffusion. So, in general what they found is for all responding lesions they show a increase in R and the O and now responding ____ of a little change, or decrease in R and also is the R changes the correlating waste of a later tumor volume change and there's another study from the same group and they did the study in rats and tried to look at it an even earlier response like this data collected before the other treatment and the square and the triangle data points representing data collected on day one and day two on the day of some of the

chemicals therapy. Definitely the difference in the responder is observable on many differences of B volume greater than 1000. For now responder you barely can distinguish anything, so this also suggests a high B volume maybe is more sensitive to standard changes and also we mentioned before is os a white matter trial you can use some color on scheme to represent that they are orientations. So, in this case you can use the red color to indicate a fiber going left to right and the blue is indicating the plane and the green is anterior to posterior and so this type of diffusion tensor technique has been actually applied to study mainly of a neurological disease. I gave you one earlier of a studies and this is a study they tried to use of diffusion tensor imaging assessed on a study of the _____ deficient. So what they found is they found the bilateral reduction in

the RA in the both parietal and temporal readings, but they found only left region this occurred with reading ability. So, later on we did one study in a normal subject. If this structure is _____ of reading ability in the department _____ in the normal subject which shows a hemisphere of laterization. That's actually we say an RA is definitely much bigger in the left compared to right and so I have to show you some other _____ is because they produce such pretty images. This is five years ago, two groups of president of first trackingography, tracking large fibers in the rats and the humans and today they can produce the fiber track of _____ of the leading humans and definitely a disease,

these types of techniques will help us understanding of function connectivity in the brain. However, whether this type of technique have any application in the tumor cases still

answer the question. Here is one study of attempt to try to look at anastrophic diffusion in the _____ patients and the tumor is near one of the large of the fibers and so definitely on the T2 weighted images you see a lot of edema and so on and when you are mapping there of anastrophy diffusion, definitely it's so you see a lot of decrease in the RA. However, how we're gonna use this type of information is still unclear and in the clinical cases, a stroke case is slightly different and the people already used this type of technique, looking at stroke lesions and so there's yellow with a relationship with cortical spinal track and use that kind of information and they can actually try to predict the recovery after stroke. So, in summary diffusion in a stroke definitely has show it's

valuable clinical diagnosis to and also it's can characterize the TCO evolution over the course of ischemia and have a potential to predict the functional recovery and the DTI may provide additional information upon that and mainly studies start to show the potential of the diffusion imaging can predict the early response of a therapy perhaps the heavy volume has more sensitivity and however, diffusion cancer imaging the road to potential tensor imaging in the cancer treatment, cancer diagnosis is still unclear and needed to be further explored. Thank you!