THE IMPACT OF VARYING TRACT TURNING ANGLE ON FIBRE TRACTOGRAPHY RECONSTRUCTION AND DIFFUSION TENSOR IMAGING INDICES

BY

NUR'AIN NURJANNAH BINTI TOKEMIN

Dissertation submitted in partial fulfillment of the requirements for the degree of Bachelor of Health Sciences

(Medical Radiation)

JUNE 2016

CERTIFICATE

This is to certify that the dissertation entitled

The Impact of Varying Tract Turning Angle on Fibre Tractography Reconstruction and Diffusion Tensor Imaging Indices

is the bona fida record of research work done by

NUR'AIN NURJANNAH BINTI TOKEMIN

during the period of February 2016 to May 2016

under our supervision

Supervisor

Dr. Nur Hartini Binti Mohd Taib
Lecterur School of Health Sciences,
Universiti Sains Malaysia, 16150,
Kubang Kerian, Kelantan.
Date:

ACKNOWLEDGMENT

This dissertation would not have been accomplished without kind support and help from many individuals. I would like to extend my sincere thanks to all of them.

First and foremost, I would like to express this gratitude to Allah S.W.T for the wisdom he bestowed upon me, strength, peace of my mind and good health during the completion of this research.

My utmost appreciation also goes to my supervisor, Dr. Nur Hartini Mohd Taib for her guidance and constant supervision as well as providing information regarding this research & also for her support to complete this endeavor. I am highly indebted to Mrs. Suzana Mat Isa for the time and knowledge she imparted to guide me during the process of data collection.

Getting through dissertation required more than academic support, hence I would like to express my gratitude and appreciation towards my beloved family who served as my inspiration to pursue this undertaking. My supportive friends, Ms. Fatin Ayuni Binti Hanapi and Ms. Sharmila A/P Sandra Sakaran who helped me a lot in making this study. Thank you for every single person who made this research success.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADC	Apparent Diffusion Coefficient
CC	Corpus Callosum
CST	Corticospinal tract
DTI	Diffusion Tensor Imaging
FA	Fractional Anisotropy
FACT	Fiber Assignment by Continuous Tracking
MD	Mean Diffusivity
ROI	Region of Interest

ABSTRACT

Impact of varying turning angle in fibre tractography reconstruction was evaluated. Diffusion tensor images were obtained retrospectively from NordicIce (version 2.3.9, Nordic Neuro Lab) database available in AMDI-USM. All data were acquired using GE 1.5 Tesla MRI system (Signa HDxt, GE Healthcare). A healthy female subject with no associated neurological or brain illness participated in the study. DTI post processing was performed in which DTI parametric maps and fibre tractography were reconstructed. During fibre tracking, tract turning angle was varied for 25°, 35°, 45° (default turning angle set by software developer), 55° and 65°. Then, the assessment was performed on DTI indices including fractional anisotropy (FA), mean diffusivity (MD) as well as number of fibres reconstructed. The values obtained for each angle were compared with that of obtained using default angle. Tractographies of corpus callosum (CC) and corticospinal tract (CST) were initiated by placement of single seed region of interest (ROI) on CC, cerebral peduncle and centrum semiovale at superior part of brain. Results obtained showed modification of turning angle from its default value has less impact on CC. There were no differences in FA noted between the default angle with angle 35°, 55° and 65°. Besides, MD showed decreases in percentage difference as the turning angle became large. Similar to number of fibres which exhibited decrease in percentage from 8.4% at smallest angle to 3% at the largest angle. However, the differences were not too significant. While for CST, small differences were noted at 35° and 55°. Whereas larger percentage difference was found at 25° with 5.4%, 1.44% and 30.3% for FA, MD and number of fibres respectively. Followed by 65° with 1.62%, 0.19% and 16.2% for FA, MD and number fibres respectively. In conclusion, the modifications of tract turning angle do give impact on reconstruction of CST fibre bundle while lesser impact was seen on CC fibre bundles.

ABSTRAK

Kesan perubahan sudut yang berbeza-beza terhadap pembinaan tractography telah di nilai. Imej pengimejan tensor peresapan (DTI) telah diperolehi secara retrospektif melalui pangkalan data NordicIce (versi 2.3.9, Nordic Neuro Lab) yang terdapat di IPPT-USM. Semua data diperolehi menggunakan system GE 1.5 Tesla (Signa HDxt, GE Healthcare). Subjek terlibat merupakan seorang wanita sihat dan tidak mempunyai sebarang penyakit yang berkaitan dengan saraf ataupun otak. Pemprosesan DTI telah dilakukan di mana peta parametric DTI dan gentian tractography telah di bina. Semasa proses dilakukan, saluran beralih sudut telah di ubah mengunakan sudut 25°, 35°, 45° (saluran beralih sudut yang ditetapkan oleh pemaju perisian), 55° and 65°. Kemudian, penilaian telah dilakukan ke atas indeks DTI termasuk pecahan anisotropi (FA), min penyerapan (MD) dan juga nilai gentian yang dibina. Nilai-nilai yang diperolehi bagi setiap sudut dibandingkan dengan nilai yang diperolehi menggunakan sudut yang ditetapkan oleh perisian. Tractography karpus callosum (CC) dan saluran kortikospina (CST) telah dimulakan dengan meletakkan daya tarikan rantau (ROI) pada CC, gagang bunga serebrum dan semiovale centrum pada bahagian atas otak. Keputusan yang diperolehi menunjukkan pegubahsuaian sudut daripada sudut asal kurang memberi kesan terhadap CC. Tiada perbezaan dalam FA yang dapat dikenal pasti diantara sudut asal dengan sudut 35°, 55° dan 65°. MD juga menunjukkan penurunan peratusan perbezaan apabila sudut semakin membesar. Sama seperti bilangan gentian yang turut mempamerkan penurunan peratusan daripada nilai 8.4% pada sudut yang paling kecil kepada 3% pada sudut yang paling besar. Walau bagaimanapun, perbezaan yang ditunjukkan adalah tidak terlalu ketara. Manakala bagi CST, perbezaan kecil dapat diperhatikan pada sudut 35° dan 55°. Sementara peratusan perbezaan yang besar dapat diperhatikan pada sudut 25° dengan nilai 5.4%, 1.44% dan 30.3% bagi FA, MD dan bilangan

gentian. Kemudian diikuti oleh 65^{o} dengan nilai 1.62%, 0.19% dan 16.2% bagi FA, MD dan bilangan gentian. Kesimpulannya, pengubahsuaian saluran beralih sudut memberi kesan terhadap pembinaan CST dan kurang dilihat pada berkas gentian CC.

CHAPTER 1

INTRODUCTION

1.0 Background of Study

Diffusion Tensor Imaging (DTI) is an advanced magnetic resonance imaging (MRI) technique. Recently, it has been used as a tool for brain imaging. By using DTI, a set of MRI images can be acquired with diffusion-weighting applied along many different directions. This will enables complete characterization of diffusion in anisotropic systems of brain (Hartini et *al.*, 2012). Main advantage of DTI over other conventional MRI techniques is it provides scalar values and anisotropy indices. Examples of scalar values are eigenvalues ($\lambda 1$, $\lambda 2$ and $\lambda 3$ that represent diffusion along three tensor principle axes), trace and mean diffusivity (MD) which characterize the molecular diffusivity. These parameters are calculated in each image voxel (Huppi & Dubois, 2006).

While an example of anisotropy indices are fractional anisotropy (FA) and relative anisotropy (RA) that describe molecular diffusivity in various directions. It permits the visualization of neuronal fibers through fiber tractography. Besides the quantitative information, there is also a unique advantage of DTI in which fibre tractography can be performed. Via fibre tractography, the neuronal fibres in the brain are visualizable (Jones et *al.*, 1999; Le Bihan et *al.*, 2001). MD, RA and FA are orientation independent specifically. They will not be affected by the position of subject under MR scanner (Huppi & Dubois, 2006). Instead, the reconstruction and

connectivity of white matter in brain areas will be influenced by DTI acquisition parameters (Hartini, 2015) and tractography algorithm (Mukherjee et *al.*, 2008).

2.0 Problem Statements

During fibre tracking process, the information from scalar and anisotropy indices will be used to reconstruct the fibre tracts. These reconstruction processes have their own criteria which are called as stopping or termination criteria. Most of tractography algorithm uses these criteria to track the white matter fibres using DTI. However, there is still no consensus of how to select the finest reconstruction method until now. Single modification to parameter during post-processing algorithm can result into change in the final product even when the acquisition parameters are similar. Moreover, different outputs may lead into different clinical decisions (Rodrigues et *al.*, 2012).

There are many studies on impact of varying the FA threshold but little investigation into the effect of varying the turning angle. Therefore, the aim for this study is to observe the impact of varying turning angle in tractography reconstruction. Turning angle range from 25° to 65° was used to reconstruct the fibres. Larger values might be necessary to define smoothness of white matter pathway properly. However, larger maximum turning angles may also dramatically increase the number of spurious tracks (Mukherjee et *al.*, 2008). The assessment was performed on MD and FA as well as number of fibers reconstructed.

3.0 Aim and Objectives

(a) Aim:

To observe and evaluate the impact of varying tract turning angle on Diffusion Tensor Imaging (DTI) parameter indices and tractography.

(b) Objectives:

1. To reconstruct DTI parametric maps and fibre tractography.
2. To measure MD, FA and number of fibres for each turning angle.
3. To compare that measured in (2) with that obtained by using default turning angle.

CHAPTER 2

LITERATURE REVIEW

2.1 White Matter of Brain

Recently, DTI has become a new powerful tool to investigate the white matter architecture in health and disease. According to Mori et *al.* (2010), Diffusion Tensor Imaging (DTI) has a unique capability to delineate axonal tracts within the white matter. White matter consists of axonal fibers that connect different regions of the brain. Axons that share similar destinations tend to form large bundle, which is called a white matter tract. They also consist of various types of neuroglia and other small cells populations. Therefore, at the core and thickest regions of the tracts, they are visually readily can be identified.

Mori and Zijl (2002) also reported that image resolution is sufficiently high for white matter tracts to contain several voxels. Even a single voxel within a single white matter tract will have a very inhomogeneous environment due to distribution of water molecules between the cells and extracellular space (80-85% are intracellular). Inside axon water molecules are surrounded by high concentration of neuronal filaments which are polymers of protein molecules. The neuronal filament is far larger than the molecular weight of monomer of protein and multiple of them are densely packed in the axon.

Moreover, the axonal membrane together with well-aligned protein fibers within an axon constrains the water diffusion perpendicular to the fiber orientation causing to anisotropic diffusion. Myelin sheaths enclose the axons may also lead to anisotropy for both intra- and extracellular water. In previous studies, DTI shows that water diffusion in white matter is highly anisotropic. Hence, when studying axonal architecture using DTI it is essential to understand the limitations that arise from inhomogeneity of water environment.

2.2 Theory of Diffusion Imaging

According to Scholz (2007), diffusion weighted imaging is based on random movement of molecules that happened due to internal thermal energy. It is also known as "Brownian Motion" which refers to random displacement of molecules in a free medium. They can be described by a three-dimensional Gaussian distribution that depends on molecule's mass, temperature and medium's viscosity. Basically, an unrestricted diffusion process is described by diffusion coefficient, D that also related to mean squared displacement (RMSD) of freely diffusing molecules over the diffusion time, t by $RMSD = (6\ D\ t_{diff})^{1/2}$.

Similar to Scholz (2007), Mukherjee et *al.* (2008) also reported that diffusion is "Brownian Motion" which refers to constant random microscopic molecular motion due to heat. Equation of $\langle r^2 \rangle = 6Dt$ is used to describe rate of diffusion during fixed temperature. $\langle r^2 \rangle$ refers to mean square displacement of molecules, t is diffusion time and D is diffusion constant, a constant proportionality for the particular substance being measured.

On the other hand, Apparent Diffusion Coefficient (ADC) is the diffusion constant that measured during clinical setting. Mukherjee et *al.* (2008) stated that, the constant diffusion cannot be separated from other sources of water mobility such as active transport, flow along pressure gradients and changes in membrane permeability. Besides, experimental parameter like voxel size also can influences the actual diffusion coefficient of water molecule (Scholz, 2007).

In presence of anisotropic diffusion, molecular movement is not equal in all directions due to white matter tract that has densely packed fibre bundles hinder the water displacement perpendicular to direction of fibres. Hence, diffusion can no longer characterized by the ADC. Mukherjee et *al.* (2008) claimed that more than 1 diffusion-encoding direction is needed to characterize the anisotropy diffusion. This can be done by using diffusion tensor.

Tensor is a mathematic construct which describe the properties of an ellipsoid. Diffusion ellipsoid is a shape defined by 6 variables which described the ADC of water molecules in each direction at particular time. If at least 6 diffusion encoded images set are obtained along noncollinear directions, in addition to at least one b = 0 s/mm^2 (or low) image set, the diffusion tensor can be calculated.

Scholz (2007) reported that measuring a large number of directions (30-90) can reduce the signal-to-noise dependence on directions and increase the angular resolution. The diffusion tensor can be characterized with an elongated ellipsoid model indicating a greater mean distance along

the longest axis of ellipsoid. Main, medium and minor axes of ellipsoid correspond to tensor's eigenvectors e_1, e_2 and e_3 and the respective eigenvalues λ_1, λ_2 and λ_3.

2.3 DTI Fibre Tracking

The main purpose of DTI fibre tracking is to relate the local tensor information in such a way that the resulting "virtual" fibres are identical to underlying neuroanatomy and/or connection probability between different regions can be inferred (Scholz, 2007). Formally, fibre tracking uses the diffusion tensor in each voxel to follow an axonal tract in 3D from voxel to voxel through human brain. Functional and/or higher resolutions of anatomic information are frequently combined in DTI fibre tracking to describe specific pathways (Mukherjee et *al.*, 2008).

DTI fibre tracking algorithms can be divided into deterministic and probabilistic. In deterministic method, the neighboring voxels are connected by propagating primary eigenvector from initial seed point until the termination criteria met. Basically, the seed point selection can be described as region of interest (ROI) and that can be generated on basis of anatomical or functional data. The termination point includes excessive angular deviation from one voxel to next or anisotropy below certain threshold value.

As stated by Mukherjee et *al.* (2008), Fibre assignment by continuous tracking (FACT) is one of deterministic method in which it capable to initiate fibre trajectories from user-defined voxels. In this technique, the tracking is initiated by selection of 3D in voxel space in which the

tract traced is in forward and backward direction. However, the 3D consists of discrete voxels. Therefore, a line must be propagated from initial voxel along the direction of vector until it exits to next voxel. Once the propagated lines through each voxels are made continuous, it will represent the fibre projection.

The line propagation meets the termination criteria when it enters the area where the average vector product contained in neighboring voxels is lower than the predefined value. In other word, it can be said that the anisotropy value is below certain threshold. The second type of approach to track the white matter fibre is probabilistic method. This method has similar approaches as deterministic since it has seed point, line propagation and termination point.

Based from Scholz (2007) study, probabilistic method is difference from deterministic in terms of, firstly, thousands line are propagated from each point. Second, the tensor information used for line propagation is varied non-deterministically from pass to pass. Third, the output contain map that represent the probability of connection between seen and target points. This method can be achieved by utilizing Monte Carlo technique. However, the fibre orientation will be based on probability density function (PDF) that provides the local uncertainty of fibre orientation.

2.4 Anisotropy Indices

The visualization of microstructure and architecture of each voxel in DTI data can be done by using scalar and anisotropy indices. They are including MD, FA and RA. Taoka et *al.* (2009) conducted a study about threshold dependence in tract based diffusion tensor analysis. They used Alzheimer and healthy subjects for their study. During the study, they measured the mean FA and apparent diffusion coefficient (ADC) along uncinate fasciculus with varied FA threshold. Then, the correlation between diffusion tensor parameters (FA and ADC) with Mini-Mental State Examination (MMSE) scores is evaluated.

They found that, a higher FA will lead to a lower mean ADC and higher mean FA value along uncinate fasciculus. However, the FA threshold not influenced the order of measured value according severity of Alzheimer. An FA threshold 0.2 showed higher correlation between mean ADC values and MME scores. Meanwhile, FA threshold 0.15 and 0.2 showed higher correlation between mean FA values and MME scores. Hence, they concluded that selection of appropriate FA threshold leads to higher correlation between diffusion tensor parameters and severity of AD.

In another study, Sollmann et *al.* (2016) evaluated the feasibility of navigated transcranial magnetic stimulation (nTMS) based DTI fibre tracking for subcortical language pathways by FA protocol. The study was performed on 37 patients suffering from left-sided perisylvian brain lesion. Minimum fibre length was set at 110 mm and the FA value was varied during the fibre tracking. At the end of the study, they found that by using 100% FA threshold, the mean percentage of visualized tracts was 13.5%. Meanwhile, DTI fibre tracking that used

75%, 50% and 25% FA threshold detected 30.6%, 61.3% and 93.7% of language-related fibre tracts respectively. The study showed an increasing visualization of white matter tract as the value of FA threshold reduced. This trend displays a similarity to the study reported by Taoka et *al.* (2009) as the higher FA threshold resulted into lower mean ADC and vice versa.

2.5 Tract Turning Angle

Rodrigues et *al.* (2012) studied about the impact of maximum turning angle in different deterministic tractography algorithms applied in pediatric populations. They used data from patients with 3 Tesla Siemens MRI scan that collected from birth to age 6 years during 2007 to 2011 intervals. Twenty-two of them were performed by using 12 non-collinear directions (7 normal and 15 abnormal scans) and 10 with 60 direction (3 normal and 7 abnormal. The abnormal include hypoxic-ischemic injury, metabolic disorder, hydrocephalus, tuberous sclerosis, polycrogyria, focal cortical dysplasis and low grade glioma.

The fibre tracking was reconstructed on Diffusion toolkit using diffusion tensor model and four deterministic algorithms. Then, the turning angle thresholds were varied with 30, 45 and 80 degrees. By using the FACT algorithm, they found that 45-degree angle threshold could regularly visualize the tract while lower angle threshold were not able to demonstrate termination of fibre reaching the cortex. On the other hand, higher angles resulted into false continuity of fibres. Hence, they concluded that the optimal angle threshold for tractography may change when using different deterministic post-processing algorithms and may change when analyzing different fibre bundles.

Dennis et *al.* (2015) also have done a study regarding the fibre turning angle. The study was about the effects of permissible fiber turning angle on white matter of traumatic brain injury. They examined the integrity of white matter over a range of fibre turning angles to see how extent this parameter can affect the ability to detect group differences. The studied participants included those in post-acute phase and chronic phase. In post-acute phase, they included 29 TBI (traumatic brain injury) participants (9 female) and 30 controls (15 female). While in chronic phase, the participants included 17 TBI (4 female) and 22 controls (7 female).

The whole-brain tractography was performed by using Camino. They varied the maximum fibre turning angle and running separate experiments. Maximum fibre turning angle are 30°/voxel, 40°/voxel, 50°/voxel and 60°/voxel. The tracing stopped when FA dropped below 0.2 as is standard in the field. They reported that, at higher fibre turning angle thresholds, more fibres are visualized indicating a larger search area for group analyses. However, it can be due to many inaccurate fibres included. While at lower fibre turning angle, fewer fibres are visualized.

This is may be due to miss the part where group differences exist and exclude more false positive fibres. They also found that the strongest group results at 30° indicating more "non-useful" and "non-discriminative" fibres included at higher fibre angle thresholds

CHAPTER 3

MATERIALS AND METHOD

3.1 Data

A retrospective study was used in this study. The data consist of DTI and T1-weighted image obtained using 1.5 Tesla MRI System (Signa HDxt, GE Healthcare) available at Advanced Medical and Dental Institute Universiti Sains Malaysia (AMDI-USM). The images retrieved from USM PACS system were sent to an independent workstation for post processing and further analysis. Post processing and analysis were carried out by using commercial software, Osirix version 4.1.2. The subject was healthy female aged 30.5 years old when the scan was performed. Subject also never had any illness that associated with brain or neurological.

3.2 DTI Protocols

The DTI data was acquired using the protocols shown in Table 3.2. A parallel imaging technique, specifically Array Spatial Sensitivity Encoding Technique (ASSET) with acceleration factor (R) of 2 was applied during the scanning to shorten the scan time.

Table 3.2. DTI protocols.

TR	**13 000 ms**
TE	**90.1 (set by vendor subject to b-value used)**
FOV	240 x 240 mm
Matrix	**96 x 96**
Slice Thickness	2.5 mm
Inter Slice Spacing	**0**
No. of diffusion encoding directions	30
No. of non-diffusion-weighted images	**3**
b-value	700 s/mm^2

3.3 Fibre Tracking Parameters

Table 3.3 shows the termination criteria set by the software developer. FA and tract turning angle are two importance parameter that need to be considered during fibre tracking. Tensor model is assumed invalid at low FA value. Thus, when FA threshold is applied it will prevent the algorithm from tracking into area where the primary eigenvector is poorly identified. While track turning angle is importance in avoiding the recognition of highly circuitous tracts. Constraining maximum turning angle with minimum FA threshold for propagation of streamline within voxel will allow the fibre track to contain the regions of brain where diffusion tensor model realistically represent the white matter pathways (Mukherjee et *al.*, 2008).

Table 3.3. Termination criteria including fractional anisotropy (FA), tract turning angle and minimum fibre length. Only track turning angle was varied during fibre tracking.

Table 3.3 Termination Criteria	
Fractional Anisotropy	< 0.180
Tract Turning Angle	> 30
Minimum Fibre Length (mm)	10

3.4 Data Analysis

Data analysis was performed using commercial software NordicICE (version 2.3.9, Nordic Neuro Lab) available in AMDI-USM. Selected data from NordicIce database was directly used for image analysis as shown in Figure 3.4.1 to 3.4.4. During the pre-processing step, firstly, the software performed denoising in which the noise level cutoff was set by user. Then, smoothing was carried out in order to reduce the noise in data images followed by motion correction and eddy current motion (Figure 3.4.5 to 3.4.7). The purpose was to correct any motion artifact or image distortion (Hartini et *al.*, 2012).

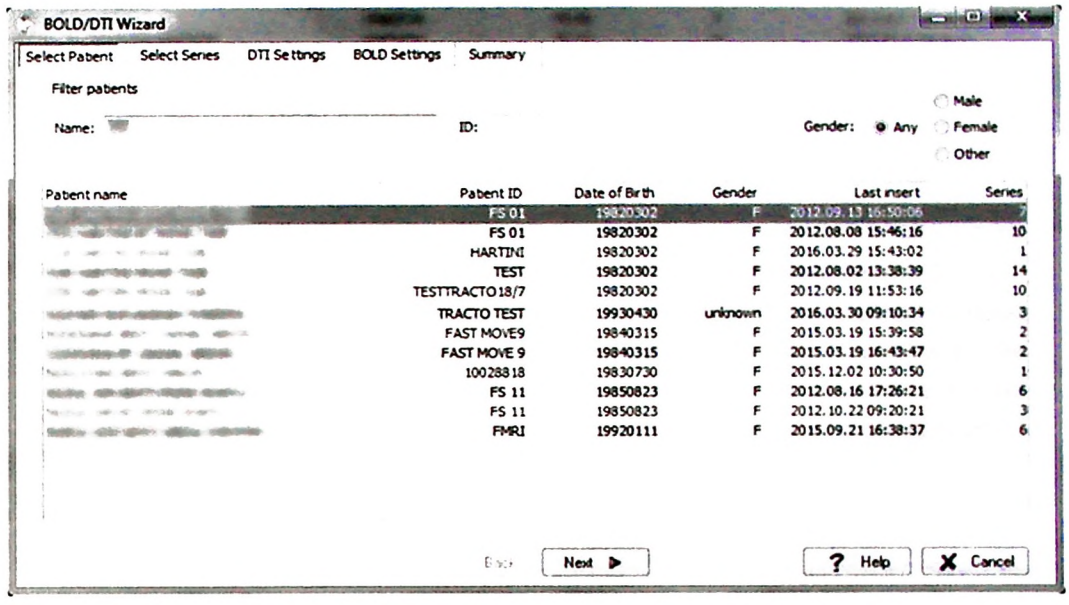

Figure 3.4.1. Selection of data from NordicIce database in IPPT

Figure 3.4.2 shows that DTI and structural images that were selected during series selection consists of 4 and 6 series respectively.

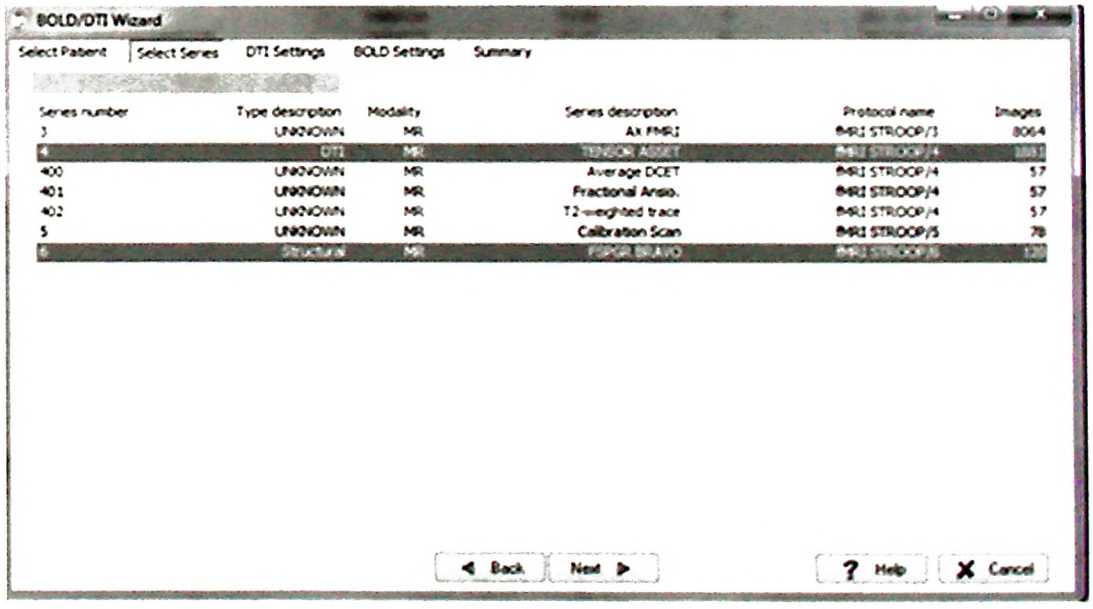

Figure 3.4.2. Series selection

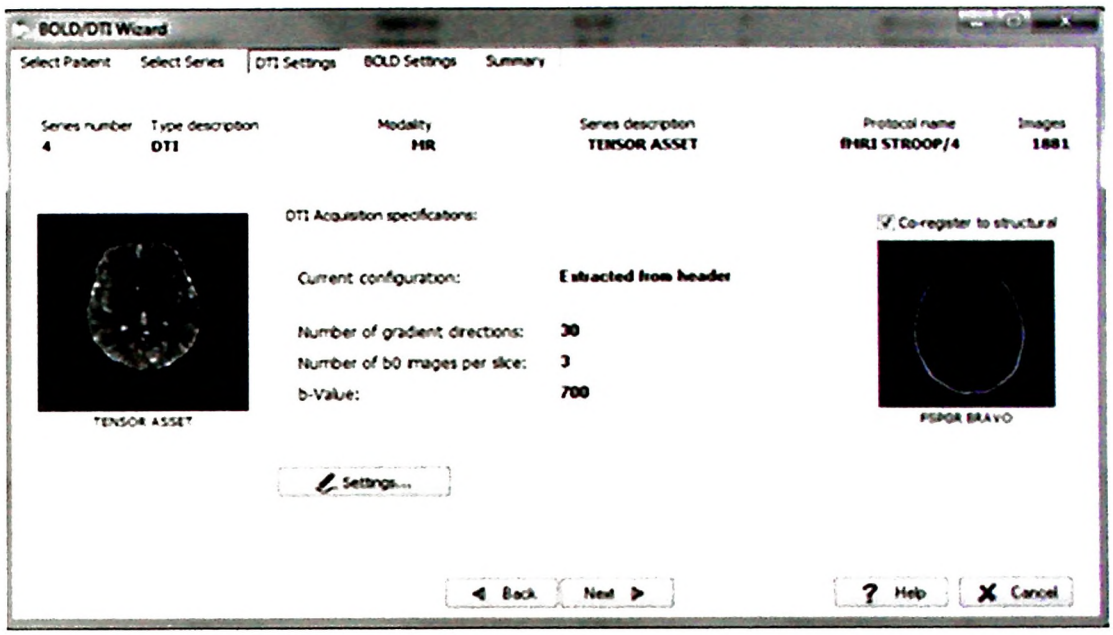

Figure 3.4.3. DTI settings.

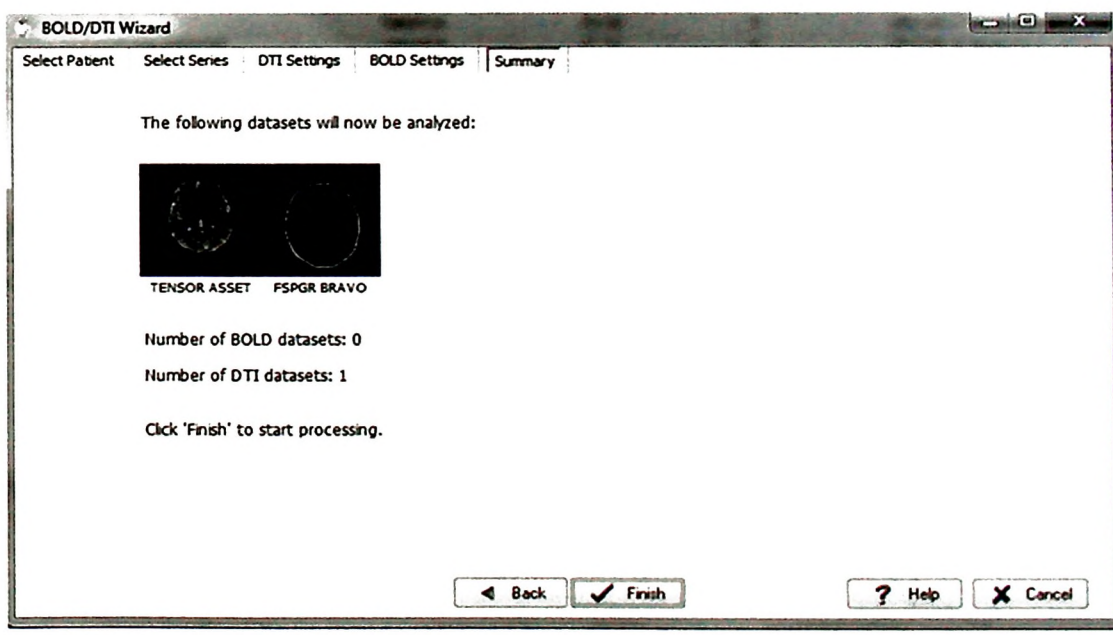

Figure 3.4.4. Summary of data protocols for DTI images

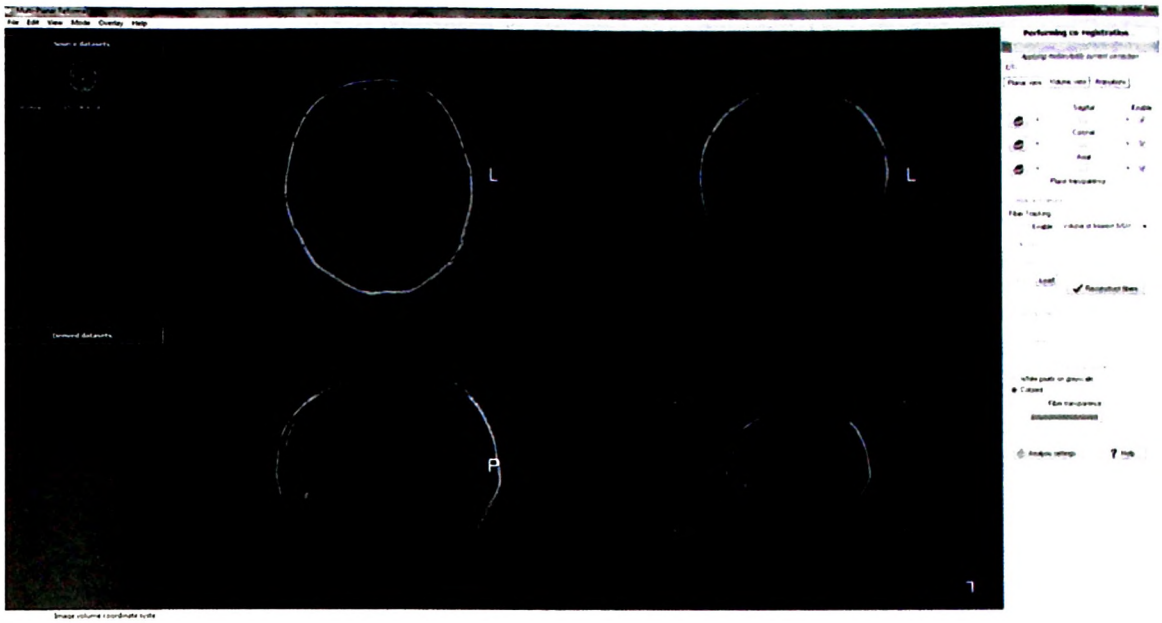

Figure 3.4.5. Application of motion/eddy current correction.

Co-registration was also performed to overlay the DTI images with structural images.

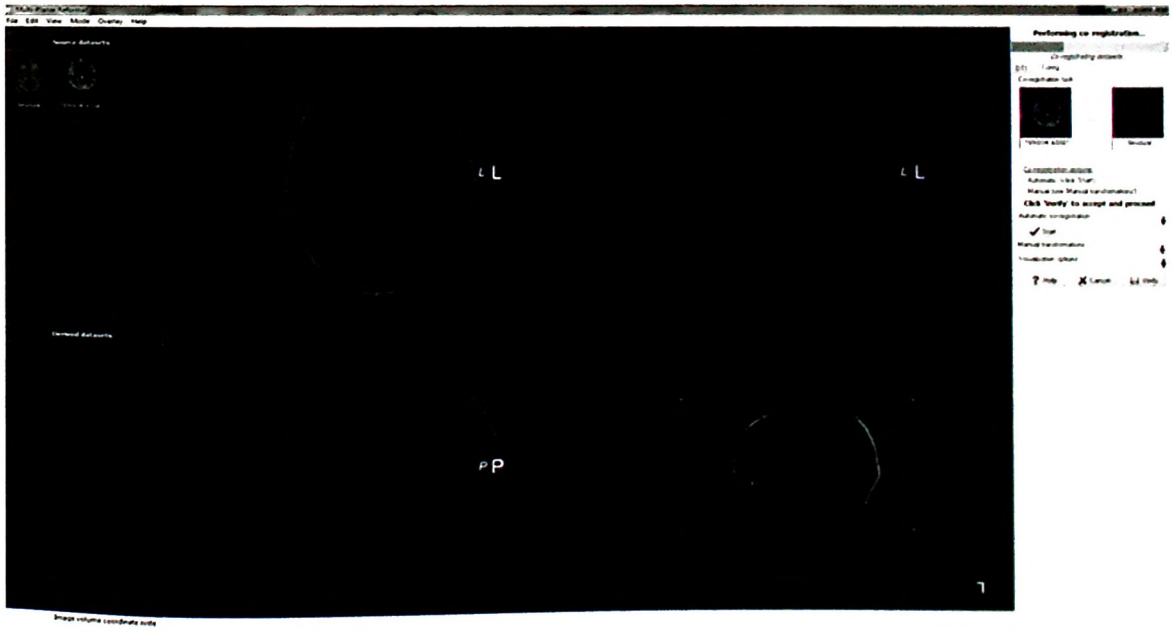

Figure 3.4.6. Co-registration process.

Diffusion data was analyzed as shown in figure 3.4.7 in which DTI values, particularly λ_1, λ_2, λ_3 axial, radial diffusivity, mean diffusivity and fractional anisotropy were computed by the software. The corresponding DTI maps then were reconstructed.

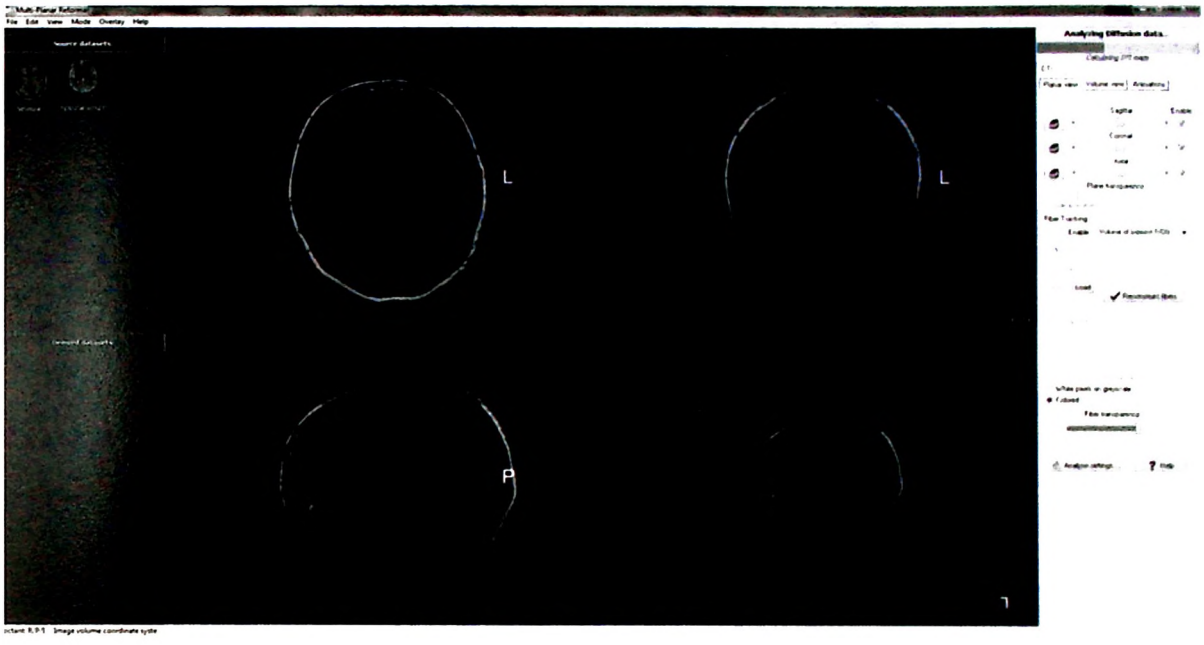

Figure 3.4.7. Calculation of DTI maps.

3.5 Fibre Tractography

(a) Corpus Callosum

To begin the fibre tracking analysis, all fiber tracking criteria were fixed according to default value set by the software developer. Specifically, the FA threshold was set to 0.18 and minimum fibre length was set to 10 mm. Only the observed parameter, that is the tract turning angle was varied for 25°, 35°, 45° (default value), 55° and 65°. Then, fibre tracking analyses were started with the tract turning angle 25° as shown in Figure 3.5.1.

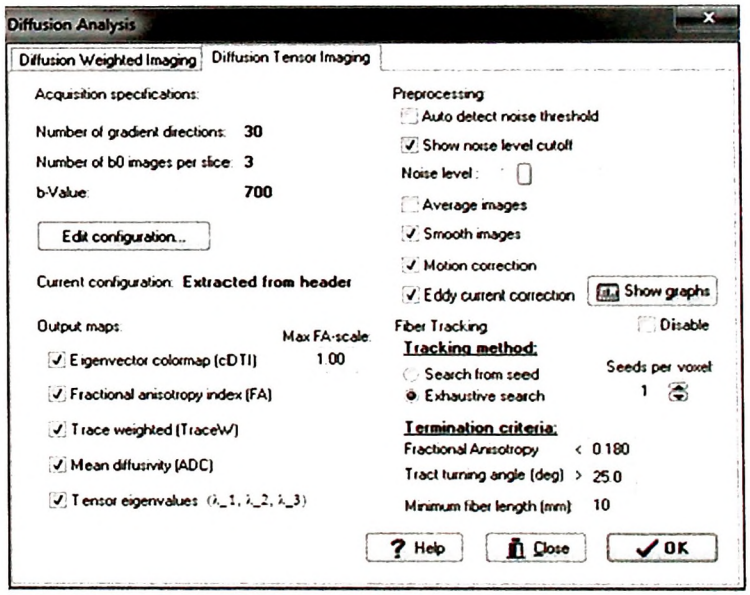

Figure 3.5.1 Analysis setting for 25° turning angle.

Figure 3.5.2 shows the steps taken and selection that has been made during tracking of fibre bundles. At this stage, firstly, the color-coded DTI map (cDTI) was dragged into the Multi Planar Reconstruction (MPR) window. Then, "Region of Interest" was selected at "Fibre Tracking" tab in order to draw free hand region of interest (ROI). Next, the "Enable" tab was checked. Fibre tracking was started by drawing seed of region of interest (ROI) manually on cDTI map (Figure 3.5.3). The FA threshold was 0.18 with maximum turning angle of 25°. After drawing of single ROI (region of interest) at corpus callosum on the left sagittal image done, "Add ROI" and "Reconstruct fibers" were selected. After that, the fibre tractography were displayed as shown in Figure 3.5.4 and 3.5.5. The number of fibers, FA, ADC and eigenvalues were displayed by the software.

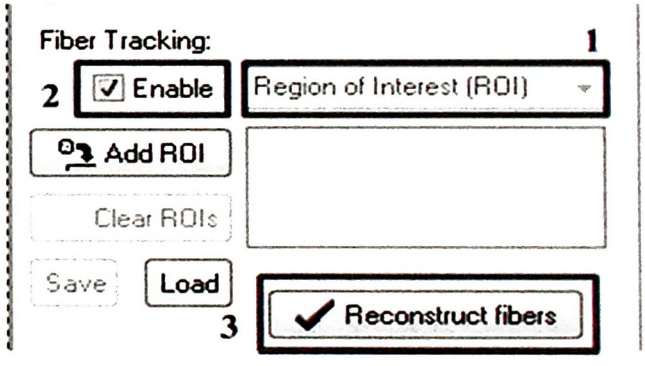

Figure 3.5.2. Steps on how to reconstruct fibers for corpus callosum.

Figure 3.5.3. Image shows corpus callosum site for drawing of ROI on sagittal view.

Figure 3.5.4. Fiber reconstruction after drawing of ROI on sagittal view.

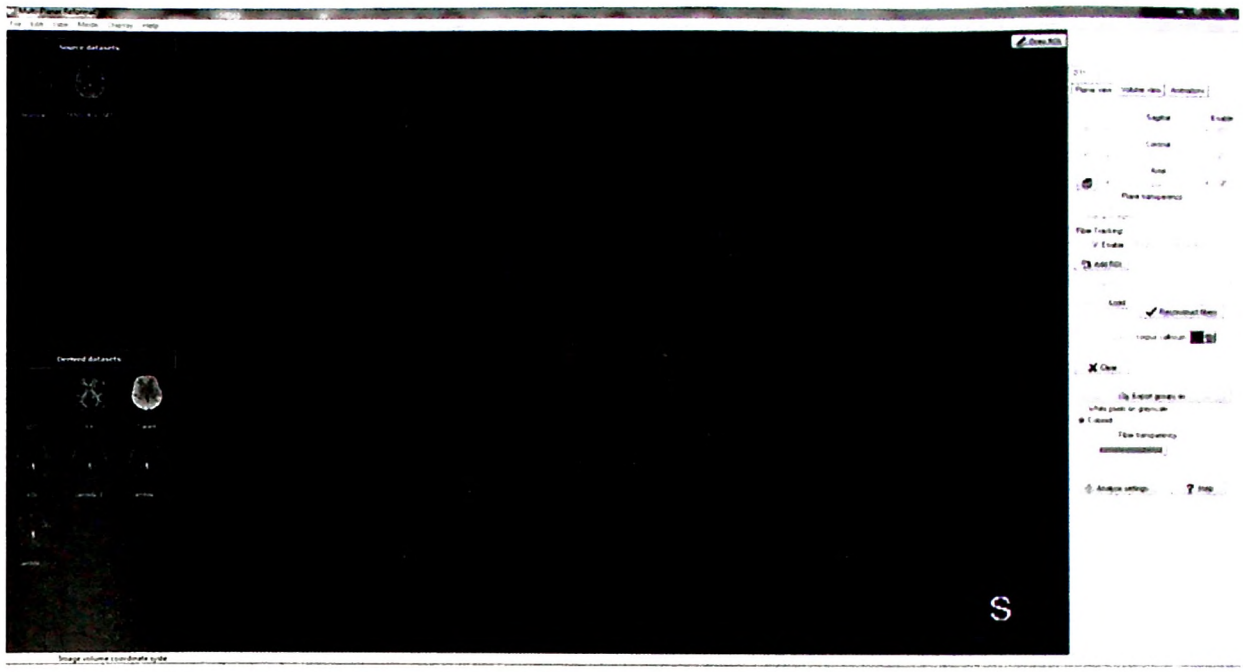

Figure 3.5.5. Fibre reconstruction for axial view.

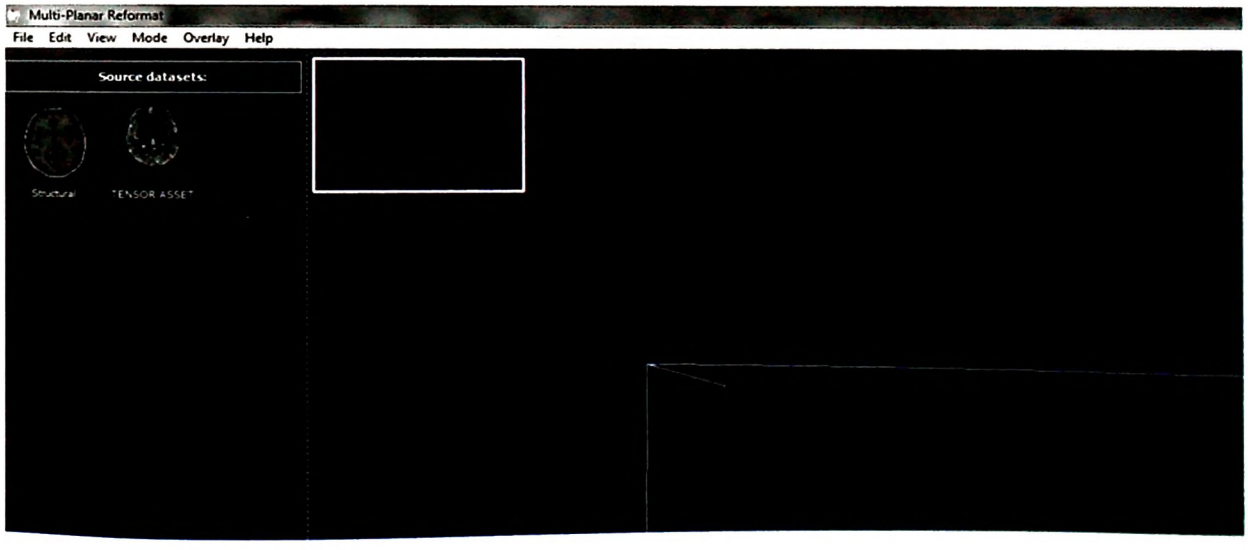

Figure 3.5.6. Arrow shows the number of fibres, FA, MD and eigenvalues computed by software.

The same steps were repeated for tract turning angle 35°,45°,55° and 65°.

(b) Corticospinal Tract

Firstly, the fiber tracking criteria were set similar to corpus callosum with the tract turning angle 25° (Figure 3.5.1). Then, "Region of Interest" was selected at "Fibre Tracking" tab and "Enable tab" was checked.

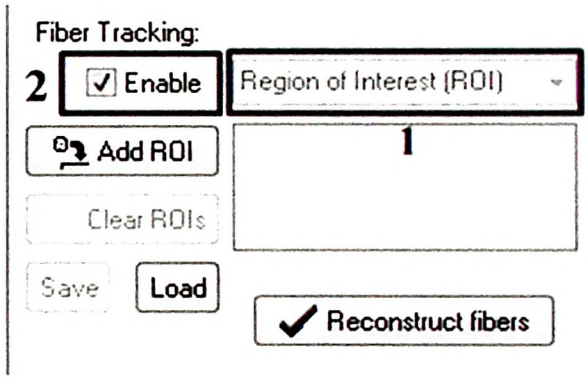

Figure 3.5.7. Steps to draw free hand ROI.

The first ROI was drawn manually at cerebral peduncle site on axial image of cDTI map. Then procedure continued by drawing second ROI at the centrum semiovale superior part of brain (Figure 3.5.8). "Attribute logic" 'AND' at "Fiber Tracking" tab was chosen for ROI 1 while, attribute logic 'NOT' for ROI 2. Next, "Group Fibers" was clicked to categorize the fibres according to their specific bundle together as shown in Figure 3.5.9.

Figure 3.5.8. Image shows drawing of ROI 1 and ROI 2 on cDTI axial view.

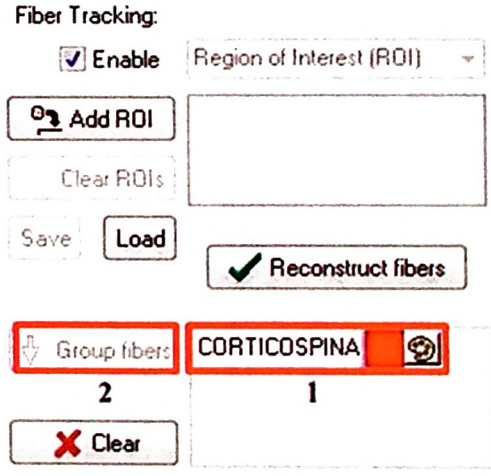

Figure 3.5.9. Steps to reconstruct fibers for corticospinal tract.