CASE REPORT

MR imaging of psychosurgery: rostral atrophy following stereotactic subcaudate tractotomy

¹K A CAULEY, MD, PhD, ²W WAHEED, MD, ³M SALMELA, MD and ³C G FILIPPI, MD

¹Department of Radiology, Division of Neuroradiology, University of Massachusetts Medical Center, MA USA,

²Department of Neurology, Fletcher Allen Healthcare, University of Vermont College of Medicine, VT USA and

³Department of Radiology, Division of Neuroradiology, Fletcher Allen Healthcare, University of Vermont College of Medicine, VT USA

ABSTRACT. There are few reports of MR imaging findings following psychosurgery. Here, we report the findings of 3T MR imaging of the sequelae of stereotactic subcaudate tractotomy (SST). Rostral atrophy is noted on conventional imaging. Diffusion tensor (DT) tractography demonstrated no communicating white matter tracts between the inferior frontal lobes, which appeared normally as thick fibre bundles in age-matched controls. DT tractography provides a unique tool for the evaluation of sequelae of ablative psychosurgical procedures.

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Case report

A 67-year-old male was referred by his neurologist for diplopia and dizziness. The physical examination was unremarkable. The patient history was significant “stereotactic surgery for intractable depression.”

MR imaging findings demonstrated T_2 FLAIR hyperintense linear signal abnormalities that extended from frontal burr holes through the frontal lobes bilaterally, terminating just beneath the caudate nuclei (Figure 1a,b). At that level, the linear signal abnormality changed course slightly to run beneath the caudate head. With the presumption that this represented a form of psychosurgery, a literature search was performed and further history was elicited from the referring neurologist (WW).

The psychosurgery procedure had been performed at Atkinson Morley Hospital, Wimbledon, UK in 1976, to treat the patient's intractable depression. The patient believed the surgery to be a limbic leucotomy, a procedure performed at Atkinson Morley at that time [1]. However, that procedure entails two pairs of cerebral lesions, one pair placed in the cingulate area and the other in the ventromedial quadrants of the frontal lobes [2], which we did not see at imaging (Figure 2a). The single pair of linear gliotic signal abnormalities that we see were lateral to the cingulate gyri and extended beneath the caudate (Figure 2b). This finding has been described for subcaudate tractotomy [3], which was also popular in the UK at the relevant time for the treatment

of a number of indications, including intractable depression [4]. With an interest in mapping the white matter tracts in the area of the lesion, the patient was offered an MR diffusion tensor imaging (DTI) study, under institutional review board approval, which he accepted.

All images were acquired with a 3.0T Achieva system (Philips Healthcare, Best, the Netherlands). The DTI study was approved by the Committee on Human Research at our institution, and was performed with single-shot spin echo echo-planar imaging. An axial 15 direction DTI (including $b=0$, sensitivity of $b=1000$ s/mm²) of the brain was performed. Six roughly age-matched controls were studied in comparison (3 men, aged 52, 52 and 73, and 3 women, aged 51, 57 and 79). Post-processing was performed on a Philips Extended Workspace (EWS, Release 2.5.3.0). Fibre tractography was performed using single large region of interest (ROI) (approximately 2 cm) placed in the inferior frontal lobe white matter, deep to the caudate, on axial images. Single ROIs were drawn freehand, with fractional anisotropy (FA) thresholding at the default value of 0.15, a maximum angle of 27° and a minimum fibre length of 10 mm. Tracts from right-side ROI were drawn in light blue, tracts from left-side ROI are drawn in dark blue (fibre directionality is not reflected by fibre colour). Fibre tractography demonstrated thick fibre tracts traversing the corpus for all six control patients and no communicating fibres for the test case (Figure 4a,b). Diffusion tensor tractography demonstrated the absence of the communicating white matter tracts of the anterior corpus callosum, specifically the callosal rostrum, confirming the impression of rostral atrophy on the sagittal T_1 weighted images (Figure 3).

Address correspondence to: Dr Keith A Cauley, Department of Radiology, Division of Neuroradiology, University of Massachusetts Medical Center, 55 Lake Avenue North, Worcester MA 01655, USA. E-mail: keithcauley@hotmail.com

Figure 1. (a) Coronal FLAIR image. (b) Diagram illustrating the path of subcaudate tractotomy, which contrasts with those of cingulotomy or limbic leukotomy [3].

Figure 2. (a) Axial FLAIR image and (b) sagittal FLAIR image of subcaudate tractotomy.

Figure 3. Sagittal T_1 weighted images at midline for (a) a 73-year-old male control and (b) the patient with a history of stereotactic subcaudate tractotomy. Note thinning of the corpus callosum anteriorly and the atrophy of the rostrum following tractotomy.

Figure 4. Diffusion tensor tractography of (a) a 73-year-old male control and (b) the patient with a history of stereotactic subcaudate tractotomy. Note the absence of callosal connections between the frontal lobes following tractotomy.

Discussion

Stereotactic psychosurgery reached a peak of popularity in the UK in the early 1970s. At least 1300 cases of stereotactic subcaudate tractotomy (SST) were reported between 1961 and 1994 at the Geoffrey Knight Unit alone [4]. Popularity waned, and SST and limbic leucotomy have been discontinued in the UK [5]. These procedures are currently rarely reported in other parts of the world, with a case report from the Netherlands published in 2004 [6] and a longitudinal study of 18 Chinese cases from 1997–1998 published in 2008 [7].

Few reports have described the imaging features of prefrontal lobotomy, or stereotactic psychosurgery [3, 8], and this is the first report of the use of diffusion tensor tractography to map the sequelae of psychosurgery. As MRI has been proposed as a tool for stereotactic guidance of lesion placement [9], diffusion tensor tractography constitutes the next step for the characterisation of lesion placement and lesion sequelae. The target fibres for SST are the thalamofrontal pathways ([8], see also [10]), and colossal atrophy appears to be a delayed sequelae [8]. The less specific lesions of supra-orbital prefrontal lobotomy have been noted to result in secondary atrophy of the genu [8]. In our case, the very specific (inferior and medial) lesions of bilateral SST resulted in atrophy of the colossal rostrum, with correspondent loss of the interhemispheric connecting fibres seen on tractography.

Our patient reports a history of severe depression, with multiple suicide attempts, before seeking psychiatric evaluation at Massachusetts General Hospital in 1976. From there, he was referred to Atkinson Morley Hospital, London, where good results were reported for stereotactic psychosurgery. Following the procedure, he returned to work in the United States as an engineer. He reports being free of symptoms, does not take antidepressants and is without neurologic deficit. He retired in 2009 and lives with his wife in New England.

Conclusions

Ablation of selective white matter tracts is the goal of many psychosurgical procedures. Diffusion tensor

tractography is an MR imaging tool with unique ability to map white matter tracts, though it has not yet been used for evaluation of ablative psychosurgical procedures. Here, we demonstrate MR imaging findings of sequelae of SST, together with the findings of a diffusion tensor study that demonstrates focal atrophy of the rostrum of the corpus callosum. Diffusion tensor tractography demonstrates no communicating white matter tracts between the inferior frontal lobes, which normally appear as a thick fibre bundle in age-matched controls. Patients with past history of psychosurgical ablation may present for MR evaluation; and ablative psychosurgical procedures continue to be performed on a limited basis. Diffusion tensor tractography may provide a tool for evaluation of sequelae of such procedures.

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References

1. Kelly D, Richardson A, Mitchell-Heggs N. Stereotactic limbic leucotomy: neurophysiological aspects and operative technique. *Br J Psychiatry* 1973;123:133–40.
2. Bartlett J, Bridges P, Kelly D. Contemporary indications for psychosurgery. *Br J Psychiatry* 1981;138:507–11.
3. Richter EO, Davis KD, Hamani C, Hutchison WD, Dostrovsky JO, Lozano AM. Cingulotomy for psychiatric disease: microelectrode guidance, a callosal reference system for documenting lesion location, and clinical results. *Neurosurgery* 2004;54:622–8.
4. Bridges PK, Bartlett JR, Hale AS, Poynton AM, Malizia AL, Hodgkiss AD. Psychosurgery: stereotactic subcaudate tractotomy. An indispensable treatment. *Br J Psychiatry* 1994;165: 599–611.
5. Christmas D, Matthews K, Eljamel MS. Neurosurgery for mental disorder. *Br J Psychiatry* 2004;185:173–4.
6. Woerdeman PA, Willems PW, Noordmans HJ, Berkelbach van der Sprenkel JW, van Rijen PC. Frameless stereotactic subcaudate tractotomy for intractable obsessive-compulsive disorder. *Acta Neurochir (Wien)* 2006;148:633–7.
7. Cho D-Y, Wen-Yuan L, Chen CC. Limbic leukotomy for intractable major affective disorders: a 7-year follow-up study using nine comprehensive psychiatric test evaluations. *J Clin Neurosci* 2009;138:42.

8. Uchino A, Kato A, Yuzuriha T, Takashima Y, Kudo S. Cranial MR imaging of sequelae of prefrontal lobotomy. *AJNR Am J Neuroradiol* 2001;22:301–4.
9. Montoya A, Weiss AP, Price BH, Cassem EH, Dougherty DD, Nierenberg AA et al. Magnetic resonance imaging-guided stereotactic limbic leukotomy for treatment of intractable psychiatric disease. *Neurosurgery* 2002;50:1043–9.
10. Feldman RP, Alterman RL, Goodrich JT. Contemporary psychosurgery and a look to the future. *J Neurosurg* 2001;95:944–56.