3D Kinematic analysis of target directed movement of the hand in Multiple Sclerosis patients

a study on the effect of Deep Brain Stimulation

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***Abstract*—3D kinematic analysis of hand movement was used to study the quantitative effect of Thalamic Deep Brain Stimulation on the accuracy and precision of target directed movement of the hand in patients with Multiple Sclerosis. It was found that Deep Brain Stimulation may be an effective treatment to improve target directed movement of patients with severe dysmetria.**

Keywords-component; video tracking systems; Multiple Sclerosis; Deep Brain Stimulation; target-directed movement

I. INTRODUCTION

Quantitative effect of Thalamic Deep Brain Stimulation (DBS) on target directed movement of the hand in patients with Multiple Sclerosis (MS) was studied using a video tracking system. DBS is a viable treatment alternative for patients with Parkinson's disease, essential tremor, and MS tremors [1-3]. When poorly controlled, these disorders have detrimental effects on the patient's health related quality of life [4]. Besides tremor, some MS patients have ataxic hand movements [5,6]. Dysmetria, an ataxic disorder, deteriorates target directed movements of the hands, which significantly reduces patient's quality of life.

Some investigators have studied kinematics of tremulous and ataxic hand movements [7-11]. The effects of DBS on tremor in MS patients have been studied [12]. It has been found that DBS decreases hand tremor in MS patients. But, it is not clear yet that DBS has any positive effect on dysmetria in a goal directed movement of the hand. In this study, 3D kinematic analysis of hand movement is used to investigate the effect of DBS on the accuracy and precision of such movements in MS patients.

II. METHOD

Infrared markers were placed on the tip of index finger of both right and left hands of 6 healthy and 7 MS patients using DBS (table I). Ten cycles of chin-to-target movement, a common clinical maneuver, was performed three times by each arm of each subject. Target was a fixed marker in the level of chin and 30 centimeters away from subject. Patients completed the test with their DBS in "on" and "off" states. A video tracking system (Optotrak™, NDI, Waterloo, Canada) recorded the spatial position of the markers during the test for 15 seconds with frequency of 100 Hz.

For each arm of each subject, "average radial distance" and "average radial deviation" from target were respectively computed as measures of accuracy and precision of the target directed movement. These measures were respectively defined as mean value and standard deviation of the relative radial positions of finger marker with respect to the target marker in the vicinity of the target (i.e. when their relative distance in movement direction is less than 5 mm) in all cycles and trials.

Mean value of "average radial distance" and "average radial deviation" were separately computed for healthy group, and contralateral and ipsilateral sides to DBS for patient groups with DBS on and off states.

Analysis of variance (ANOVA) was implemented to check the repeatability of tests for 3 trials. Significance of difference between the means of the measures for contralateral and ipsilateral arms of the patients with DBS on and DBS off was checked by paired t-test.

TABLE I. DBS SIDE, AGE AND GENDER FOR THE PATIENTS TESTED.

Patient	DBS side	Gender	Age
ga	Bilateral	M	34
ir	Bilateral	M	52
gc	Left	M	32
sw	Left	F	38
ck	Left	F	67
dl	Left	F	42
lk	Right	F	62

III. RESULTS

ANOVA confirmed repeatability of tests for "average radial distance" and "average radial deviation" (P=0.021 and P=0.027, respectively). Both measures were mostly greater for the patients compared to average of the healthy subjects, and reduced for most of the patients when the DBS was in on state, in both contralateral and ipsilateral arms (Fig 1).

Mean value of both measures were greatest in patients with DBS off in both contralateral and ipsilateral arms, and least in healthy subjects. P-values resulting from paired t-tests between DBS on and off states showed that the mean values of "average radial distance" and "average radial deviation" were significantly different for contralateral arm (P=0.028 and P=0.050, respectively) but were not significantly different for ipsilateral arm (P=0.083 and P=0.124, respectively).

IV. DISCUSSION

In few patients, who had measures in the level of healthy subjects, turning the DBS on had either no or little reverse effect, i.e. decreasing accuracy and precision of goal directed movement. On the other hand, DBS decreased the measures, i.e. increased accuracy and precision, in patients with high radial distance and deviation from the target.

In average, DBS had no significant effect on ipsilateral arm, but increased accuracy and precision of target directed movement in patients' contralateral arm. These findings indicate the positive effect of DBS on contralateral arm of patients with high dysmetria.

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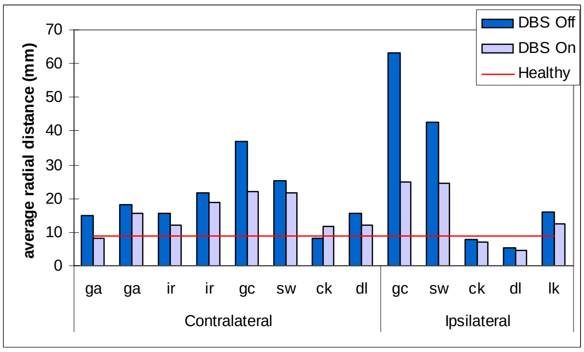

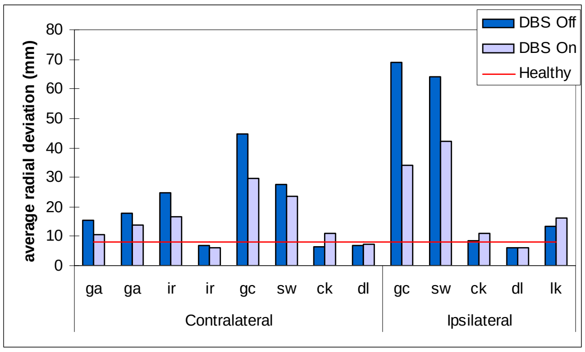

Figure 1. *"average radial distance" (top), and "average radial deviation" (bottom), for contralateral and ipsilateral arms of each patient with DBS on and off, compared to mean of the healthy (red line).*