The Utility of the Oarm in Frameless Deep Brain Stimulation Surgery

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Introduction: Intra-operative three-dimensional imaging can provide direct patient benefits in deep brain stimulation (DBS) surgery, the most important of which is that it ensures the DBS has been placed correctly, eliminating the need for a corrective surgery. In addition, Oarm based stereotactic registration may be feasible but its accuracy is unknown. Thirdly, the use of an intra-operative fan beam CT (Oarm) allows for the detailed study of stereotactic accuracy and the factors that may effect it.

Methods: Participation was offered to 33 patients undergoing DBS surgery for movement disorders. After informed consent was obtained, 6 bone fiducials were implanted in the scalp. Their locations are indicated on the pre-operative cone beam CT as well as on the intra-operative Oarm images. These locations are matched with the real world fiducials during the registration process. The accuracy of the registration is assessed by using the N drop 1 method. Five fiducials are employed in the registration process and the 6th fiducial is employed as a target.

Analysis: The data was collected by 3 individuals and the inter- and intra-observer reliability was assessed.

The discrepancy in fiducial localization across all patients and all scans was assessed for both systematic and random errors using the mean and standard deviation of the error. Finally we analyzed the accuracy of placement of parallel tracks. In patients undergoing placement of GPi or STN leads, an image was obtained with the microcannula of the microelectrode at target. For Vim, imaging was performed with the DBS lead itself. The Oarm image was transferred to the FrameLink program and merged to the pre-operative CT. At the end of the procedure a final Oarm was obtained to observe the final DBS position. This was compared with a traditional postoperative CT scan. These errors were correlated with intracranial air, the use of simultaneous vs. sequential tracks, and error of fiducial localization on the same scan.

PreOp Center (Crosshair) vs. Oarm Center (Dot)
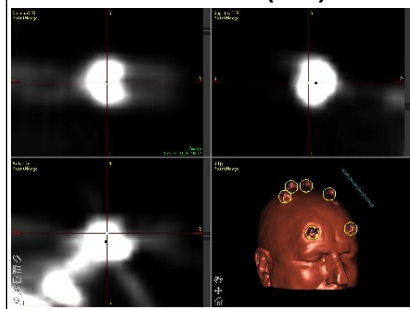
Results: The collected data shows that there is a difference in the localization of the fiducials on the intraoperative scan when compared with the localization of the fiducials on a merged preoperative CT.

Statistics of discrepancies in fiducial location between pre-op and intra-op scans. All values in mm.									
Fiducial	Mean lat	Mean a/p	Mean vert.	SD lat	SD AP	SD vert	Vector	SD Vector	Max vector error
1	0.20	0.17	-0.08	0.32	0.32	0.35	0.58	0.26	1.36
2	0.09	0.02	0.22	0.45	0.40	0.43	0.69	0.32	1.41
3	0.06	0.04	0.33	0.55	0.40	0.41	0.76	0.36	1.56
4	-0.03	0.05	0.20	0.54	0.37	0.35	0.69	0.32	1.72
5	-0.07	0.09	0.13	0.50	0.36	0.49	0.71	0.35	1.87
6	-0.02	0.40	-0.20	0.33	0.31	0.45	0.68	0.35	1.58
All							0.69	0.33	

The inter and intra-reader error was comparatively low.

|	Avg RR*	Avg R1	Avg R2	Std RR	Std R1	Std R2
Preoperative CT	0	0.22	0.15	0.13	0.13	0.15
Oarm	0	0.13	0.10	0.13	0.12	0.21

The contribution of the worst case discrepancies was evaluated using the histogram of the compound discrepancy. The top 5% of discrepancies were excluded and the average discrepancy was recomputed. This resulted in a reduction of the average value from 0.698 to 0.657 mm, so the contribution of the outliers is relatively small.

### Histogram of Compound Fiducial Discrepancy
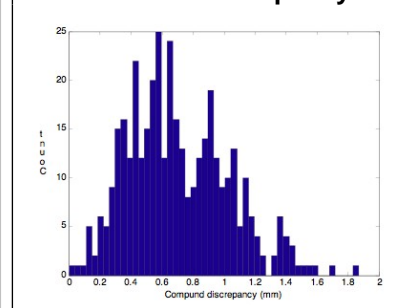
There was not much variation between patients, or between scans of a given patient. An attempt to correct the error through scaling, rotation and shift did not result in a useful reduction.

Finding the Microelectrode Tip in Oarm Scan
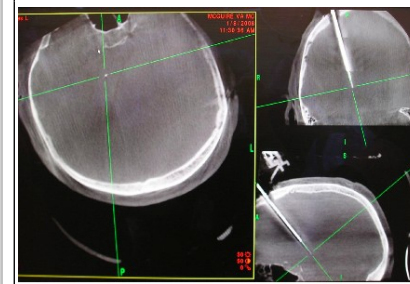
The deviation of the implant from the expected location ranged from 0.21 to 3.04 mm, with an average value of 1.16 mm and a standard deviation of 0.76 mm. Most (76%) of the values are 1.4 mm or less.

Histogram of Compound Microelectrode Tip Deviation
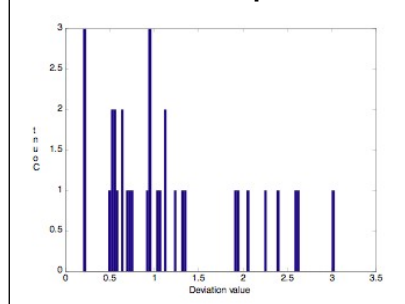
An attempt was made to correlate the deviation with the intracranial air vs. the change in intracranial air.

While there is no one-to-one relationship between variables, a weak general positive correlation exists. The normalized correlation coefficient is 19.4% with the volume and 18.3% with the volume change. The correlation does not increase if we look at cases with simultaneous cannulas separately or if we remove the cases with no change in air volume.

DBS Tip Deviation
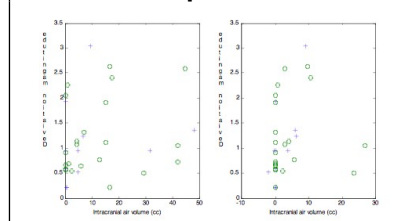
Conclusion: This study demonstrated a discrepancy in fiducial location on Oarm images merged to the preoperative CT which averaged 0.69 (sd 0.33). It was not possible to correct for this error. Registration based on an Oarm image has an error of 0.87 as compared with a CT based error of 0.70; this is statistically significant. Oarm images were able to detect the 24% of parallel tracks that were > 2mm outside of the expected location.