Use of the Putamen as Surrogate Anatomical Marker for the GPi in DBS Surgery

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Introduction

The success of deep brain stimulation of the internal segment of globus pallidum (GPi DBS) depends on accurately placing the electrode into GPi motor territory. Direct targeting can be difficult as GPi laminar borders are not always clearly identifiable on T1 and T2 MRI. Here, we report a method for using the putamen (PUT) as a surrogate anatomical marker to identify GPi, when tissue contrast is inadequate for direct visualization of the GPi DBS target.

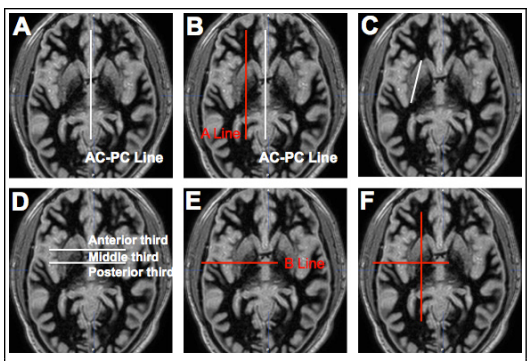

Figure 1: Workflow of putamen-based GPi targeting. A, The line connecting anterior (AC) and posterior commissure (PC) was drawn; B, A line (A) was drawn through the anterior pole of PUT and parallel to the AC-PC line; C, The distance between the anterior pole and tail of PUT was measured; D, PUT was then divided into anterior, middle and posterior thirds; E, A second line (B) was drawn through the border between middle and posterior thirds of PUT; F, The intersection of A and B, called target (T)-point corresponded to the location for DBS contact 0 in GPi.

Methods

Six patients with Parkinson's disease (n=5) or essential tremor (n=1) were included in this retrospective study. PUT-based GPi targeting was developed using the FGATIR MR sequence (Phillips 1.5T). An axial midline, connecting anterior (AC) and posterior commissure (PC), was drawn, followed by a line (A) through the anterior pole of PUT and parallel to the AC-PC line. The axial length of PUT was then divided into anterior, middle and posterior thirds. A second line (B) was drawn through the border between middle and posterior thirds of PUT. The intersection of A and B, called target (T)-point corresponded to the optimal location for DBS contact 0 in GPi, based on literature (1-3). In the axial plane, the distance from target in the GPi to the pallidocapsular border (PCB) (PUT-based target-to-PCB) and the central width of the GPi (WIDTHc) was measured. GPi targeting was compared using PUT-based method vs. consensus coordinate-based indirect targeting. Stereotactic target coordinates were obtained and analyzed.

Results I

1. PUT and GPi in all cases were visualized clearly on FGATIR MRI. GPi borders were unresolvable on T2-weighted MRI; however, in all cases, application of the PUT-based method resulted in consistently localization of GPi targets, which were confirmed by merging the T2-weighted MRI with the FGATIR MRI. The distance of PUT-based target to PCB ranged from 3.0 to 3.7 mm with mean distance of 3.3±0.3 mm on the left side, and from 2.0 to 3.4 mm with mean distance of 2.8±0.6 mm on the right side.

Results II

2. The WIDTHc ranged from 3.6 to 4.4 mm with mean distance of 4.2±0.3 mm on the left side, and from 3.7 to 4.6 mm with mean distance of 4.0±0.3 mm on the right side.
3. The frame coordinates (X, Y and Z) for GPi were 84.7±1.8 mm, 108.4±4.6 mm and 113.2±15.4 mm for PUT-based method, and 82.7±1.4 mm, 104.9±4.3 mm and 120.1±14.1 mm for indirect targeting. Significant differences were noted in Y and Z target coordinates between PUT-based method and indirect targeting (p=0.02 and 0.02), but not for X. The mean differences for X, Y and Z were 1.5 mm, 3.3 mm and 6.0 mm.

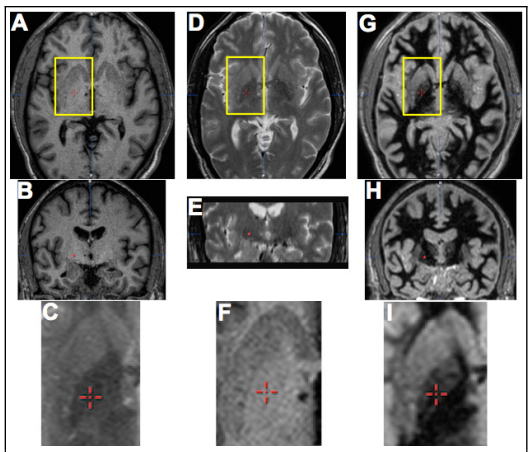

Figure 2: Putamen-based left GPi targeting on T1- and T2-weighted MRI, confirmed with being merged onto FGATIR. A, D, and G: Axial MRI. B, E and H: Coronal MRI. C, F and I are the enlargement of yellow frame in A, D, and G, respectively.

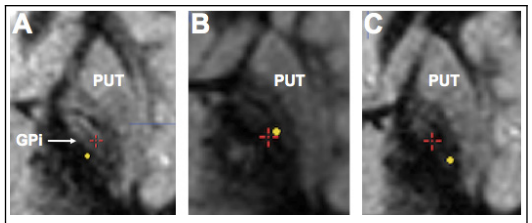

Figure 3: Comparison of GPi targeting between putamen-based method and indirect method in different patients. A, B and C showed the target location of these two methods. The red cruciate mark represents target from putamen-based method. The yellow solid circle represent target from indirect method.

Conclusions

1. PUT can be used as an MRI marker for targeting GPi when GPi is not clearly visualized.
2. Our PUT-based method allows consistent and precise patient-specific GPi targeting.
3. Further study is planned to correlate PUT-based GPi targeting with microelectrode recording, location of active contact of DBS electrode and clinical outcome.

References

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