REVIEW

The effect of deep brain stimulation on quality of life in movement disorders

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J Neurol Neurosurg Psychiatry 2005;**76**:1188–1193. doi: 10.1136/jnnp.2005.065334

Deep brain stimulation (DBS) is a viable treatment alternative for patients with Parkinson's disease (PD), essential tremor (ET), dystonia, and cerebellar outflow tremors. When poorly controlled, these disorders have detrimental effects on the patient's health related quality of life (HRQoL). Instruments that measure HRQoL are useful tools to assess burden of disease and the impact of therapeutic interventions on activities of daily living, employment, and other functions. We systematically and critically reviewed the literature on the effects of DBS on HRQoL in PD, ET, dystonia, and cerebellar outflow tremor related to multiple sclerosis.

That high frequency stimulation of the thalamus suppresses tremor associated with Parkinson's disease (PD) has been recognised since the early attempts to treat movement disorders by ablative procedures in the 1960s.[1 2] Deep brain stimulation (DBS), however, was not utilised as a viable alternative to ablative therapies until the early 1990s.[3] This procedure is now the preferred surgical approach in patients with PD who experience troublesome levodopa related motor complications, and in patients with severe essential tremor (ET) and other medically intractable, disabling disorders, such as dystonia, cerebellar outflow tremor, and hemiballism. When these movement disorders cannot be adequately controlled with available treatments, they may have profoundly detrimental effects on patients' health related quality of life (HRQoL), defined by the World Health Organization as ''perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns''.[4] Instruments that measure HRQoL allow clinicians to understand the burden of the disease and serve as useful tools for assessing the impact of therapeutic interventions on activities of daily living (ADL), employment, and other functions.[5] There are two types of HRQoL instruments, generic and disease specific. Generic instruments are multidimensional questionnaires that cover a wide variety of areas and can be applied to many diseases. Although these allow comparisons between diseases,[5] they lack sensitivity in areas important to patients with movement disorders. Disease specific HRQoL questionnaires are tailored to what a particular patient population feels is important; therefore, they allow more accurate information regarding the impact of a disease on the overall health burden.[5] The primary objective of this paper is to systematically and critically review the available literature on the effects of DBS on HRQoL in ET, PD, dystonia, and cerebellar outflow tremor related to multiple sclerosis (MS). For in-depth discussion on the individual HRQoL instruments discussed in this article, we direct the readers to other reviews.[6 7]

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Received 10 February 2005
Revised version received 10 February 2005
Accepted 25 April 2005

METHODS

We reviewed the literature in English from 1965 to 2005 using the following sources to identify clinical studies: Medline, Pre-medline, Sociofile, Psych Info, Health and Psychosocial instruments, Healthstar, the Cochrane Library, and reference lists of included publications. We used the following search terms: Parkinson's disease, ET, dystonia, and MS combined with surgery, DBS, treatment, subthalamic nucleus (STN), globus pallidus (GPi), thalamus (Vim) AND quality of life, patient reported, satisfaction, preference, and health status. The identified articles were then reviewed to verify that they included patient reported outcomes; those that did not were excluded. The review was restricted to articles assessing HRQoL instruments in PD treated with STN-DBS, Vim-DBS, or GPi-DBS; ET and MS treated with Vim-DBS; and dystonia treated with GPi-DBS. The level of evidence was rated using criteria adapted from the Oxford Centre for Evidence-Based Medicine (table 1).[8]

RESULTS

Parkinson's disease

Parkinson's disease is a chronic, progressive neurological disorder characterised by tremor, bradykinesia, postural instability, and rigidity. Features that strongly influence HRQoL in PD are progressive motor impairments, depression, anxiety, and mobility.[9] In PD, there is a strong association between motor complications with deterioration of HRQoL and advancing stages of

Abbreviations: ADL, activities of daily living; BAI, Beck's Anxiety Index; BDI, Beck Depression Index; BFMD, Burke-Fahn-Marsden dystonia scale; DBS, deep brain stimulation; ET, essential tremor; GPi, globus pallidus; HRQoL, health related quality of life; MS, multiple sclerosis; NHP, Nottingham Health Profile; PD, Parkinson's disease; PMS, Profile of Mood State; QUEST, Quality of Life in Essential Tremor Questionnaire; SF-36, Medical Outcomes Study 36-item Short-Form General Health Survey; SIP, Sickness Impact Profile; STN, subthalamic nucleus; TWSTR Scale, Toronto Western Spasmodic Torticollis Rating Scale; Vim, ventral intermediate nucleus of the thalamus

Table 1 Evidence-Based Medicine criteria

Level	Description
1a	Systematic review of randomised controlled trials
1b	Randomised controlled trial
2	Cohort study (consecutive patients) or low quality randomised controlled trial (for example, <80% follow up)
3	Open label, non-randomised study with historical or other control group or open label study using convenience (that is, non-consecutive) or unspecified sample; cohort studies with five or fewer patients
4	Case series (that is, not designed as a clinical study; typically including five or fewer patients)

Adapted from the Oxford Centre for Evidence-Based Medicine criteria.[8]

the disease.[10–13] In addition to their detrimental impact on HRQoL, progressive motor impairments disrupt mobility and ADL,[14] which restricts patients' independence leading to an increased reliance on caregivers.[9]

We identified 13 prospective studies that assessed HRQoL as an outcome in patients with STN-DBS. We excluded five of these as two were not available in English[15 16] and three lacked sufficient detail to be included.[17–19] Of the remaining eight articles, there were various levels of evidence; only one study provided class 1b evidence[20] and the remaining seven were categorised as class 2[21–26] (table 2). In the class 1b study, 34 patients were randomised to unilateral pallidotomy or bilateral STN-DBS.[20] The Parkinson's Disease Quality of Life questionnaire (PDQL) was a secondary outcome. Both groups showed similar improvements in mean PDQL total scores at 3 months (13 *v* 18 (maximum score of 185) for unilateral pallidotomy and STN-DBS, respectively). Although the STN-DBS treated patients failed to show statistically significant improvement in HRQoL over unilateral pallidotomy, there was a trend towards significance ($p = 0.15$). This was felt to be due to the lack of statistical power. Individual PDQL subscores were not mentioned. Additionally, the STN-DBS group was favoured in *off* Unified Parkinson's Disease Rating Scale (UPDRS) score and *on* dyskinesias.

In a class 2 study, using a generic HRQoL instrument, 16 consecutive patients were treated with bilateral STN-DBS.[25] The Sickness Impact Profile (SIP) total score showed a 58% ($p<0.05$) improvement at 6 months.[25] Furthermore, there were 67% ($p<0.05$) and 51% ($p = NS$) improvements in physical and psychosocial dimensions, respectively. Items most improved assessed body care and movement, sleep and rest, ambulation, social interaction, and recreation and pastimes. Another class 2 study, which utilised the PDQL to assess 60 consecutive patients treated with bilateral STN-DBS, showed a 43% ($p<0.001$) improvement in total PDQL score at 12 months.[22] Furthermore, all dimensions of the PDQL improved: social function (63%; $p<0.001$), PD related symptoms (48%; $p<0.001$), systemic symptoms (34%; $p<0.001$), and emotional functioning (29%; $p<0.001$). There was a significant improvement in depression after surgery.

A total of 84 patients in five class 2 studies with STN-DBS were evaluated with the Parkinson's Disease Questionnaire 39 (PDQ-39) instrument[21 23 24 26 27] (tables 2 and 3). Compared with preoperative scores, improvements of up to 62% were reported in the PDQ-39 Summary Index (PDQ-39SI).[21 23 24 26 27] Mobility, ADL, stigma, emotional wellbeing, and bodily discomfort showed consistently greater improvements, whereas social support, cognition, and communication were less improved. Tröster *et al* found the improvements in PDQ-39SI correlated with improvements in depression rather than in motor function.[26] In contrast, others have found improvements in levodopa induced motor complications and UPDRS scores correlated with improvements in the PDQ-39SI whereas depression and anxiety did not.[23 27]

In a class 3 study, 39 patients with PD were treated with unilateral pallidotomy ($n = 23$), unilateral GPi-DBS ($n = 9$), or unilateral Vim-DBS ($n = 7$; see below).[28] The surgical option was selected based on the patient's symptoms (that is, tremor dominant PD was treated with Vim-DBS). In the unilateral GPi-DBS treated group, the mean SIP total score (improved from 21.6 to 10.9; $p = 0.021$) and SIP physical impairment score (improved from 23.3 to 9.4; $p = 0.008$) showed significant improvements, while the SIP psychosocial impairment score showed only a trend towards improvement (from 21.2 to 12.4; $p = 0.086$). In addition, depression and anxiety as measured by Beck's Anxiety Index (BAI) (from 18.2 to 11.9; $p = 0.007$) and the Beck Depression Index (BDI) (from 9.9 to 7.0; $p = 0.067$) also improved, although the latter did not reach statistical significance.

Two studies have assessed the effects of Vim-DBS on the HRQoL in patients with PD (table 2).

Table 2 Quality of Life in Parkinson's disease

Reference	Class	Target	n	Age, mean (years)	Mean duration of disease (years)	HRQoL tool	Follow up (months)	HRQoL improvements
Esselink *et al*[20]	1b	STN	S = 20 P = 14	S: 61 (55–66) P: 62 (57–68)	S: 12 (9–17) P: 11 (9–16)	PDQL	6	Mean total score improvement of 13 and 18 in P and S, respectively
Lagrange *et al*[22]	2	STN	60	56 (SD 10)	14 (SD 8)	PDQL	12	Total score improved 43%*
Spottke *et al*[25]	2	STN	16	56 (SD 8.5)	10.8 (SD 3.9)	SIP	6	Total score improved 58%*
Martinez-Martin *et al*[23]	2	STN	17	60.9 (43–74)	16.4 (7–38)	PDQ-39	6	Total score improved 49%*
Patel *et al*[24]	2	STN	16	56 (SD 11)	10 (SD 3.5)	PDQ-39	12	Total score improved 14%*
Just and Ostergaard[21]	2	STN	S = 11 M = 13	S: 59.8 (51.8–70.9) M: 61.4 (53.8–69.2)	S: 14 (7–25) M: 16 (10–27)	PDQ-39	3, 6	Mean total score improved 16.1*† in the surgically and –0.4*† in the medically treated groups
Tröster *et al*[26]	2	STN	26	56.6 (SD 11)	9.5 (SD 4.9)	PDQ-39	3	Total score improved from 42.8 to 29.4*†
Lezcano *et al*[27]	2	STN	14	63.2 (SD 8.6)	14.3 (SD 5)	PDQ-39	12, 24	Total score improved 62%*
Woods *et al*[29]	3	Vim	6	70.83 (SD 8.75)	7.33 (SD 2.66)	PDQ-39	12	PDQ-39SI non-significant improvement
Straits-Troster *et al*[28]	3	Vim	7	65.1 (SD 12.0)	8 (SD 3.8)	SIP	3	Total SIP score non-significant improvement
Straits-Troster *et al*[28]	3	GPi	9	50.3 (SD 13)	10.3 (SD 4.9)	SIP	3	Total SIP score improved*

GPi, globus pallidus; M, medically treated; NA, not available; P, unilateral pallidotomy; PDQ-39SI, Parkinson's Disease Questionnaire Summary Index; PDQL, Parkinson's Disease Quality of Life questionnaire; S, STN-DBS; SF-36, Medical Outcomes Study 36-item Short-Form General Health Survey; SIP, Sickness Impact Profile; STN, subthalamic nucleus; v, Spanish version; Vim, thalamus.
*$p<0.05$.
†Mean score improvement.

Table 3 STN-DBS and PDQ-39 subscores

Reference	PDQ-39 subscore† improvement
Martinez-Martin *et al*[23]	Mob 60.5%* EWB 21.99%* BD 40.64%* Stigma 29.52%* ADL 69.21%*
Patel *et al*[24]	ADL 30%* Stigma 21%*
Just and Ostergaard[21]	Surgical Mob 26.8*‡ Cog 15.3*‡ BD 15.1*‡ ADL 38.6*‡ EWB 9.5*‡ Stigma 15.9*‡ Medical: NS
Lezcano *et al*[27]	Mob 53%* EWB 58%* BD 63%* ADL 81%* Stigma 38%* Com 60%*

*p<0.05.
†PDQ-39 subscales: mobility (Mob), activities of daily living (ADL), emotional wellbeing (EWB), stigma, cognition (Cog), communication (Com), bodily discomfort (BD).
‡Mean score improvement.
NS, not significant.

In a class 3 study, six of 11 patients with unilateral Vim-DBS were assessed at 1 year with the PDQ-39.[29] At follow up, only mean ADL (improved from 52 to 28.67; p<0.05) and emotional wellbeing (improved from 40.8 to 17.5; p<0.05) dimensions were significantly improved. In addition, anxiety and depression as measured by BAI (improved from 17.2 to 12.7; p<0.05) and the BDI (improved from 10.0 to 7.3; p<0.05) were also improved.

In a class 3 study, seven patients were treated with unilateral Vim-DBS (see above) and at 3 months there were non-significant improvements in mean SIP total score (from 14.1 to 13; p = 0.735), physical dysfunction (from 10.8 to 9.1; p = 0.735), and psychosocial dysfunction (from 13.8 to 12.7; p = 0.612).[28] In addition, there was no improvement in depression as measured by the BDI (from 7.7 to 10.0; p = 0.655). This was in contrast to the pallidotomy and GPi-DBS treated groups where there were improvements in the physical dysfunction dimension and total SIP score. The authors concluded that the lack of improvement in the SIP in the Vim-DBS patients was due to the fact that tremor does not affect HRQoL as much as bradykinesia or postural instability, symptoms usually not improved with Vim-DBS. Pooled analysis of the three treatment groups revealed that the level of motor dysfunction at baseline correlated with preoperative anxiety, and preoperative depression correlated with SIP psychosocial function at baseline and follow up.

Essential tremor

ET is the most common form of tremor encountered in movement disorder clinics, and occurs in 0.4–3.9% of the general population.[30] In ET, the inability to eat or drink due to tremor may increase stress and embarrassment leading to social isolation which leads to worsening HRQoL.[31–35]

Although ET is more common than PD, HRQoL studies in ET are sparse (table 4). We identified three prospective studies, but excluded one from analysis because the patients in that study were included another study already used in this analysis.[36 37] The two articles which assessed HRQoL both presented class 2 evidence.[36 38] In one of the studies, Hariz *et al* assessed 27 patients with ET and Vim-DBS with the ADL taxonomy scale, the Nottingham Health Profile (NHP), and a visual analogue scale.[38] At follow up, which ranged from 6 to 26 months, there were significant improvements (p<0.0001) in the Tremor Rating Scale part A (53%), B (39%), and C (54%), and 79% improvement was noted in contralateral upper extremity tremor. The ADL taxonomy scale showed significant improvements in writing, putting on make-up, shaving, combing hair, reading, eating, drinking, utensils, shopping, and cooking. The NHP showed improvements in emotional reaction (from 12.3 to 7.1; p<0.05), social life (from 74 to 29.6; p<0.001), hobbies (from 77.4 to 44.4; p<0.05), and home maintenance (from 70.4 to 44.4; p<0.001). There was a 31.3 point improvement (p<0.0001) in ''life as a whole'' and a 39 point improvement (p<0.0001) in ''social life'' as measured by the visual analogue scale. Interestingly, 7.4% of patients felt surgery did not meet their expectations. Another class 2 study evaluated 40 patients with ET and unilateral Vim-DBS with the BAI, BDI, modified PDQ-39, Fahn-Tolosa-Marin Tremor Rating Scale (FTMTRS), SIP, and Profile of Mood State (PMS).[36] At 12 month follow up, there was improvement in the SIP psychosocial subscore (from 8.59 to 6.37; p<0.05), but the SIP overall score showed no improvement, and the SIP physical subscore worsened, suggesting a lack of sensitivity of the SIP in items important to patients with tremor. Although the PMS showed improvement in tension and anxiety (p<0.05) at 3 and 12 months, this was not verified with the BAI. Regarding a disease specific questionnaire, the authors used a modified PDQ-39, where they replaced the words ''Parkinson disease'' with ''essential tremor''. At 12 months, there were improvements in ADL (from 48.55 to 27.38; p<0.05), emotional wellbeing (from 23.9 to 14.38; p<0.05), and stigma (from 35.69 to 16.28; p<0.05). Although improvements in communication were present at 3 months (from 21.03 to 10.90; p<0.05), they were no longer present at 12 months. In addition, emotional wellbeing, stigma, and ADL showed subtle declines between 3 and 12 months, but these were not significant. They authors attributed the declines to a possible honeymoon effect. A significant limitation of this study is that the PDQ-39 is not designed or validated for ET. The recently validated Quality of Life in Essential Tremor Questionnaire (QUEST) is the only disease specific questionnaire for ET and should provide valuable information regarding Vim-DBS effects on HRQoL in patients with ET.[39] In addition to improving ADL, improvements in functional disability impact HRQoL.[40]

Multiple sclerosis

MS can be associated with action tremor in 50–75% of patients.[41 42] Medical treatment usually does not provide adequate long term tremor suppression.[43] Brice and McLellan reported 100% improvement in tremor suppression in two patients with MS.[44] Vim-DBS has been reported to result in suppression of tremor in 88% of patients and 76% experience improvement in ADL.[45] Even though Vim-DBS is associated with tremor improvement and less social embarrassment, this is not necessarily associated with improved overall disability.[46–48] MS is associated with poor HRQoL and patients with MS are most concerned with mental health, emotional problems, and vitality, whereas clinicians are more concerned with physical problems.[49–55] In MS, non-tremor related disabilities that affect HRQoL are gait abnormalities, pain, depression, loss of ability to work or engage in hobbies, incontinence, and stigma. Tremor can further decrease HRQoL by interfering with ADL, feeding, drinking, and hygiene.[56] Although depression, fatigue, and disability level are independent predictors of HRQoL in MS,[55] the effects of Vim-DBS have not been studied. In addition, declining cognition is associated with poorer HRQoL.[57]

We identified two studies assessing Vim-DBS effects on HRQoL in patients with MS. One was excluded because

Table 4 Quality of life in essential tremor

Reference	Class	n	Age, mean (years)	Mean duration of disease (years)	HRQoL tool	Follow up (months)	HRQoL improvements
Fields *et al*[56]	2	40	71.7 (SD 8.84)	18.14 (SD 12.88)	mPDQ-39 SIP	12	mPDQ-39SI and total SIP score showed non-significant improvement
Hariz *et al*[58]	2	27	66 (SD 11)	21 (SD 18.6)	NHP VAS	12	NHP total score not provided VAS 31.3 ''Life as a whole'' *† 36.3 ''Social life'' *† Global 70.4% improved

*p<0.05; †mean score improvement.
mPDQ-39SI, modified Parkinson's Disease Questionnaire Summary Index; NHP, Nottingham Health Profile; SIP, Sickness Impact Profile; VAS, visual analogue scale (range 0–100).

results were presented as combined thalamotomy and Vim-DBS.[58] There was one class 3 study assessing a general HRQoL instrument in MS.[59] In this study, 12 patients with MS were treated with Vim-DBS and followed for 12 months[59] (table 5). At 2 months, there were significant improvements in resting tremor (58%, $p = 0.02$), postural tremor (57%, $p<0.001$), action tremor (70%, $p<0.001$), and overall tremor severity (63%, $p<0.001$) as measured by blinded videotape assessment. These improvements were maintained for 12 months. At 2 months, there were improvements in ability to feed oneself ($p = 0.01$) and a trend for improvement in dressing ($p = 0.08$), but changes in hygiene ($p = 0.16$) and writing ($p = 0.34$) were not significant, and at 1 year, the improvement in feeding was no longer significant ($p = 0.17$). At 12 months, there were negligible improvements in the Medical Outcomes Study 36-item Short-Form General Health Survey (SF-36) summary index and eight subscales. The authors concluded that although tremor was improved at 1 year, this did not correlate with improved HRQoL or patient satisfaction, possibly due to patient expectations or ataxia being uncovered. These results are in line with previous reports of a lack of improved disability or function in the setting of improved tremor.[47 48] This is likely due to progression of MS or lack of appropriate tremor sensitive outcome measures, or because MS tremor does not make an important independent contribution to disability.

Dystonia

Treatment with GPi-DBS has been effective in patients with primary generalised dystonia,[60–66] segmental dystonia,[67] cervical dystonia (CD),[63 68] blepharospasm-oromandibular cranial dystonia,[69] myoclonus dystonia,[70] and tardive dystonia.[71] Patients with CD have poor HRQoL,[72 73] and predictors for HRQoL include self esteem, self deprecation, retired status, and disease severity.[74] In addition, depression and anxiety worsen HRQoL.[74] Longer disease duration and educational status are associated with better HRQoL, probably due to coping strategies.[74]

We identified three articles that assessed HRQoL in patients with dystonia and GPi-DBS; one was class 2, while the others were class 3 and 4 (table 5). All studies used general HRQoL questionnaires and one used a modified PD specific questionnaire. In the class 2 study, 22 consecutive patients with primary generalised dystonia who underwent bilateral GPi-DBS were assessed at 3, 6, and 12 months with the Burke-Fahn-Marsden dystonia scale (BFMD) and the SF-36.[75] There were significant improvements in mean BFMD and disability score at 12 months. The SF-36 showed significant improvements at 12 months in measures of general health (16%), physical function (21%), and vitality (10%). There were no changes in mood or cognition. In a class 3 study, four patients with generalised dystonia and one with segmental dystonia were treated with bilateral and unilateral GPi-DBS, respectively.[76] Four patients were DYT-1 negative, while one patient with generalised dystonia was DYT-1 positive. The BFMD, EuroQol 1, EuroQol 2, and PDQ-39 were assessed at 3–12 months. There was a 43% ($p<0.02$) improvement in BFMDS at follow up. The EuroQol 1 and EuroQol 2 improved by 56% ($p<0.05$) and 400% ($p<0.02$), respectively. Using a modified PDQ-39 (the words ''Parkinson disease'' were replaced with ''disease''), there was a 65% improvement ($p<0.05$) in PDQ-39SI. Dimension subscores were not available. One class 4 study, a preliminary report of two of 10 patients with CD treated with bilateral GPi-DBS, was published.[77] The first patient, a 63 year old man, had improved Toronto Western Spasmodic Torticollis Rating (TWSTR) severity (from 15 to 4), pain (from 29 to 0), and disability (from 19 to 6) scores at 1 year. The SF-36 total score improved from 82.5 to 124.4 (146 represents perfect health). The second patient, a 48 year old man, had improved

Table 5 Quality of life in dystonia and multiple sclerosis

Citation	Class	n	Age, mean (years)	Mean duration of disease (years)	HRQoL tool	Follow up (months)	HRQoL improvements
Dystonia							
Vidailhet *et al*[75]	2	22	30 (14–54)	18 (4–37)	SF-36	12	General health 16%* Physical function 21%* Vitality 10%*
Kiss *et al*[77]	4	2	63 48	14 5	SF-36	12 6	SF-36 total score 41.9 SF-36 total score 30.3
Kupsch *et al*[76]	3	5	37 (13–56)	11.8 (2–32)	mPDQ-39 EuroQol 1 EuroQol 2	3-12	PDQ-39 65%* EuroQol 1 56%* EuroQol 2 400%*
Multiple sclerosis							
Berk *et al*[59]	3	12	34.5 (28–42)	NA	SF-36	12	No change in SF-36 total score or subscores.

*p<0.05.
NA, not available; PDQ3SI, Parkinson's Disease Questionnaire Summary Index; SF-36, Medical Outcomes Study 36-item Short-Form General Health Survey.

TWSTR severity (from 14 to 6), pain (from 21 to 4), and disability (from 10 to 0) at 6 months. SF-36 improved from 95.5 to 125.8.

Summary and comments

Most studies have focused on DBS and HRQoL in PD. In PD, most effects on global HRQoL appear to correlate with improved motor complications, although psychological aspects such as improved depression and anxiety play a role as well. To date, there has been only one randomised controlled trial evaluating the HRQoL in patients with DBS.[20] Another drawback is that the PDQ-39 and PDQL questionnaires are not designed to address specific issues directly relevant to DBS, such as device inconspicuousness, controllability and reliability, the availability of qualified medical care, and safety and tolerability.[78] Furthermore, more studies are required to adequately assess the impact of anxiety and depression on patient derived outcomes. There is a paucity of studies assessing HRQoL in ET, MS, and dystonia. It is apparent that there is little consensus on which HRQoL tool to utilise as outcome measures. Even though ET is more common than PD, studies on the effects of DBS on HRQoL in patients with ET are lacking. Previous studies have used modified PD questionnaires which were not designed or validated for ET and have questions that are not pertinent to patients with ET. However, the recently designed QUEST, an ET specific questionnaire, should provide valuable information regarding HRQoL in ET patients. Concerning MS and dystonia, further work is needed to better delineate the effects of DBS on HRQoL in these disorders. A recently published disease specific HRQoL instrument designed and validated for ET, PD, and dystonia (QLSm-MD), combined with a DBS specific questionnaire (QLSm-DBS) and generic questionnaires in a modular format (QLSm-A and QLSm-G) should be utilised in future assessments of the impact of DBS on HRQoL.[78] Despite the limitations of the published studies, there is growing evidence that DBS has a favourable impact on HRQoL in patients with PD and other movement disorders.

ACKNOWLEDGEMENTS

Dr Diamond's fellowship is partially supported by Medtronic.

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Competing interests: none declared

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ADDENDUM

After submission of the revised manuscript, two additional papers (class 2 evidence) assessing HRQoL in PD patients treated with bilateral STN-DBS were published. Drapier *et al* evaluated 27 consecutive patients with the PDQ-39 and SF-36.[79] At 12 months follow up there were significant improvements in the PDQ-39SI (21.1%) and mobility (25.6%), ADL (34.5%), and stigma (40.1%) subscores. In addition, the SF-36 global score improved by 22.5%; however, only physical function (28.4%) and physical role (766.6%) subscores were significantly improved. In another study, 29 consecutive patients were evaluated with the PDQ-39 and NHP.[80] At follow up intervals of 1 and 12 months, there were significant improvements in the PDQ-39SI. Furthermore, four PDQ-39 subscores showed significant improvements: ADL, emotional well being, stigma, and bodily discomfort. There were significant improvements in NHP subscores assessing sleep, energy, emotional reaction, and social isolation. Interestingly, there was a negative correlation between the patient's age and improvements in the PDQ-39 ADL subscore ($r = 0.417$; $p = 0.031$).