Dopamine Transporter Imaging With Single-Photon Emission Computed Tomography

Policy Number: 6.01.54  Last Review: 9/2017
Origination: 9/2015  Next Review: 9/2018

Policy
Blue Cross and Blue Shield of Kansas City (Blue KC) will not provide coverage for Dopamine Transporter Imaging With Single-Photon Emission Computed Tomography. This is considered investigational.

When Policy Topic is covered
n/a

When Policy Topic is not covered
Dopamine transporter imaging with single-photon emission computed tomography (DAT-SPECT) is investigational for all indications, including but not limited to,

- aiding in the diagnosis of patients with clinically uncertain parkinsonian syndromes; OR
- distinguishing between parkinsonian syndromes and essential tremor; OR
- distinguishing between dementia with Lewy bodies and Alzheimer disease; OR
- monitoring of disease progression

Description of Procedure or Service

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Dopamine transporter imaging with single-photon emission computed tomography (DAT-SPECT), using radiopharmaceutical ioflupane I 123 injection, is being evaluated to improve the differential diagnosis of parkinsonian syndromes from nonparkinsonian tremor and of dementia with Lewy bodies from Alzheimer disease.

For individuals who have clinically uncertain Parkinson disease who receive DAT-SPECT, the evidence includes a number of studies from Europe, where a dopamine transporter (DAT) ligand has been available for over a decade. Relevant outcomes are test accuracy, symptoms, functional outcomes, and medication use. In terms of technical performance, the DAT ligand is specific for the striatal DAT, and studies have indicated reliability in assessment of the images when performed by experienced readers. Studies of diagnostic accuracy have reported good specificity for confirming nigrostriatal degeneration, with less sensitivity for ruling out disease; these findings are dependent, however, on a reference standard (clinical diagnosis), which may be flawed, and it is unknown whether DAT-SPECT would show greater sensitivity than the criterion standard (histopathologic diagnosis). Evidence on clinical utility includes a randomized controlled trial (RCT) that showed more patients evaluated with DAT-SPECT had changes in diagnosis and management than controls without imaging; however, there is limited evidence to evaluate whether these changes improve health outcomes. The evidence is insufficient to determine the effects of the technology on health outcomes.

For individuals who have clinically uncertain dementia with DLB who receive DAT-SPECT, the evidence includes studies on diagnostic accuracy and its effect on diagnosis and confidence in diagnosis. Relevant outcomes are test accuracy, symptoms, functional outcomes, and medication use. For discriminating between DLB and Alzheimer disease, the sensitivity and specificity of DAT-SPECT is somewhat lower than for parkinsonian syndromes, although the comparison standard used in the available studies may be flawed. Few patients have been evaluated with histopathology as the reference standard. Evidence on clinical utility includes an RCT that showed DAT-SPECT can influence the diagnosis of DLB, particularly when the scan is abnormal. It cannot be determined from this study whether the revised diagnosis was more accurate or resulted in a beneficial change in patient management. The evidence is insufficient to determine the effects of the technology on health outcomes.

**Background**

PSSs are a group of diseases that share similar cardinal signs, characterized by bradykinesia, rigidity, resting tremor and gait disturbance. PD is the most common cause of parkinsonism; however, diagnosing PD in the early stage of the disease can be difficult. In addition, other etiologies such as essential tremor (ET),
corticobasal degeneration, multisystem atrophy, progressive supranuclear palsy, vascular parkinsonism, and drug-induced parkinsonism can lead to a similar set of symptoms. Even in specialized movement disorders centers, up to 25% of patients may be misclassified, and some patients, such as those with ET who have been diagnosed with PD, may be erroneously treated. This has led to the development of additional tests to improve the accuracy of clinical diagnosis of PD and other PSs. One recent approach is to evaluate the integrity of dopaminergic pathways in the brain with dopamine transporter imaging with DAT-SPECT.

DAT-SPECT detects presynaptic dopaminergic deficit by measuring DAT binding. In general, striatal DAT binding is reduced in PD, genetic parkinsonism, DLB, corticobasal degeneration, progressive supranuclear palsy, and multiple system atrophy, while striatal DAT binding is in the normal range in AD, ET, dystonic tremor, orthostatic tremor, drug-induced parkinsonism, psychogenic parkinsonism, and vascular parkinsonism. It is proposed that an abnormal DAT-SPECT supports the diagnosis of PD or other neurodegenerative PS (multisystem atrophy, progressive supranuclear palsy), while a normal DAT-SPECT in a symptomatic patient increases the likelihood of a disease not affecting the nigrostriatal dopaminergic pathway.

Due to the degeneration of nigrostriatal neurons in DLB, DAT-SPECT is also proposed to differentiate DLB from AD. Some note a severe sensitivity to neuroleptics (potentially life-threatening) in patients with DLB. However, newer agents are usually well-tolerated, and patients with DLB may also respond to the cholinesterase inhibitors that are more commonly used to treat AD.

Analysis of DAT-SPECT images can be visual or semiquantitative. Since patients typically do not become symptomatic before a substantial number of striatal synapses have degenerated, visual interpretation of the scan is thought to be sufficient for clinical evaluation. A variety of methods are being tested to improve the validity and reliability of ratings, including commercially available software to define the region of interest (ROI) for semiquantitative analysis and the development of an atlas for visual interpretation. Semiquantitative interpretation may aid visual interpretation and, if performed rigorously, may increase diagnostic accuracy; however, interobserver variability tends to be high with manual ROI-based semiquantification. Semiquantitative analysis also requires normal control values and varies across imaging systems.

DAT ligands include iodine $^{123}$ 2β-carbomethoxy-3β-(4-iodophenyl) tropane ($^{123}$I-β-CIT), iodine 123 N-(3-fluoropropyl)-2β-carbomethoxy-3β-(4-iodophenyl)nortropane ($^{123}$I-FP-CIT), and technetium 99m (2β((N,N’-bis(2-mercaptoethyl) ethylene diamino)methyl), 3β-(4-chlorophenyl) tropane ($^{99}$mTc-TRODAT-1). Intravenous $^{123}$I-β-CIT requires a delay between injection and scan of about 24 hours. Intravenous 123I-FP-CIT (DaTscan™) is a fluoropropyl derivate of β-CIT that can be injected 3 to 6 hours before the scan.
Rationale
This evidence review was created in August 2012 and has been updated periodically with a search of the MEDLINE database. The most recent literature update was performed through July 24, 2016.

Assessment of a diagnostic technology typically focuses on the following 3 categories of evidence: (1) technical performance (test-retest reliability, agreement among raters); (2) diagnostic accuracy (sensitivity, specificity, positive predictive value [PPV] and negative predictive value [NPV]) in relevant populations of patients, such as those with suspected early Parkinson disease (PD) or inconclusive diagnosis; and (3) effect on patient outcomes (demonstration that the diagnostic information can be used to improve patient outcomes through a randomized controlled trial [RCT] or demonstration of a tightly linked chain of evidence from diagnostic accuracy to outcomes).

The criterion standard for the diagnosis of parkinsonian syndromes (PS) and dementia is postmortem neuropathologic examination. In the absence of comparisons with the criterion standard, long-term clinical follow-up may be used as a surrogate standard to evaluate the ability of dopamine transporter imaging with single-photon emission computed tomography (DAT-SPECT) to discriminate degenerative PS from normality or from nondegenerative disorders that present with similar symptoms, and to discriminate dementia with Lewy bodies (DLB) from Alzheimer disease (AD).

Technical Performance
DAT-SPECT is based on the selective affinity of DAT ligands and the exclusive location of the dopamine transporter (DAT) in dopamine synthesizing neurons. Iodine $^{123}$ 2β-carbomethoxy-3β-(4-iodophenyl) tropane ($^{123}$I-β-CIT) is a cocaine analogue that has a high affinity to the DAT and serotonin transporters.

Iodine $^{123}$ N-(3-fluoropropyl)-2β-carbomethoxy-3β-(4-iodophenyl)nortropane ($^{123}$I-FP-CIT) (DaTscan) is a fluoropropyl derivate of β-CIT that is selective for brain striatal DAT, but it can also bind to the serotonin transporter. Although antiparkinsonian drugs do not interfere with DAT binding, it is unknown if dopamine agonists and levodopa affect DAT expression, which could influence the ability of DAT-SPECT to monitor progression of disease.

A 2012 study evaluated interobserver variability in the visual interpretation of DAT-SPECT. Eighty-nine previously obtained DAT-SPECT scans were blindly reviewed by 3 independent observers with different levels of experience (consultant, resident doctor, radiographer), classified as “normal” or “abnormal,” and assigned visual DAT-SPECT uptake scores (2 = normal, 1 = reduced, 0 = no uptake). Results were compared with the diagnosis at last visit to the clinician, divided into PS or no PS. There was good interobserver agreement for 85 of 89 studies in classifying scans as “normal” or “abnormal” ($\kappa$ range, 0.89-0.93) and moderate agreement in assignment of uptake scores ($\kappa$ range, 0.71-0.80 for
putamina; 0.50-0.79 for caudate nuclei). All 3 observers achieved a sensitivity of 100%, with specificities of 96%, 91%, and 89%.

In 2014, Seibyl et al reported intra- and interrater agreement for DAT-SPECT images from 5 multicenter trials (total N=818 patients). DAT binding was classified as “normal” or “abnormal.” Within-reader agreement was assessed in 1 study, and showed complete (100%) agreement when image evaluation was blinded. In all trials, between-reader agreement was high (κ>0.8) for PD, but decreased when comparing blinded image evaluation and on-site readers for DLB.

A number of research centers are developing quantitative and semiquantitative classification methods for the evaluation of DAT-SPECT images.

Section Summary: Technical Performance
Preclinical studies have indicated the specificity of ligand binding for the striatal DAT. There is limited evidence on the effects of medications on DAT expression. Studies have reported a high level of interobserver agreement on visual interpretation of images for PD, suggesting that reliability of visual interpretation for this disorder is high. There was less interobserver agreement on visual interpretation of images for DLB.

Clinically Uncertain Parkinson Disease

Diagnostic Accuracy
The most informative evaluation of diagnostic performance requires prospective, independent, and blinded assessment of test results compared with a criterion standard in an appropriate population. This study design was used by Marshall et al, who in 2009 reported a prospective, investigator-initiated industry-funded, 3-year European multicenter study with repeat DAT-SPECT and criterion standard clinical diagnosis (video at 36 months by 2 movement disorders specialists) in 99 diagnostically uncertain cases of PD or essential tremor (ET). Patients with other potential causes of parkinsonism/tremor and patients with major comorbid illness were excluded; 3 healthy volunteers were included. For analysis, the clinical diagnosis was considered as either PD (including atypical PD) or non-PD (including ET, dystonic tremor, vascular parkinsonism). There was 50% loss to follow-up over the 3-year study (199 enrolled), although patients with PD were not more likely to drop out than patients without PD. DAT-SPECT scans were evaluated by 3 masked nuclear physicians using visual criteria, and the interreader agreement for rating scans as normal or abnormal was high for scans at baseline, 18 months, and 36 months (κ range, 0.94-0.97).

The 36-month criterion standard diagnosis was degenerative parkinsonism in 71 cases and non-PD in 28 cases. The initial clinical diagnosis had sensitivity of 93% and specificity of 46% compared with diagnosis at follow-up, indicating overdiagnosis of PD. DAT-SPECT at baseline had a sensitivity of 78% and specificity of 97%, with a PPV of 98.2% and an NPV of 66.2%. DAT-SPECT scans were considered normal in 21% of the cases with a criterion standard diagnosis of PD and did not change over the 3 years of the study. These cases are referred to
as scans without evidence of dopaminergic deficit (SWEDD); it cannot be
determined at this time which is more accurate for the diagnosis of these patients,
the 36-month clinical assessment or DAT-SPECT. Overall, this prospective study
was a well-conducted, indicating that an abnormal DAT-SPECT scan may help to
confirm a clinical diagnosis of PD. However, the low NPV suggests that a normal
DAT-SPECT scan cannot be used to rule out disease. Thus, this test may not be
helpful in preventing the potential clinical overdiagnosis of PD.

In 2015, Jakobson et al prospectively studied the diagnostic accuracy of visual
assessment of DAT-SPECT in individuals with early-stage parkinsonian diseases.\textsuperscript{10}
Strengths of this study included an independent clinical diagnosis made at baseline
and follow-up, and blinded reading of the DAT scans. Patients (N=171) were
identified incidentally from an ongoing longitudinal population-based research
project on parkinsonian disorders. All met criteria for stage 1 disease on the U.K.
Parkinson’s Disease Society Brain Bank clinical criteria for PD. Patients with a Mini-
Mental State Examination scores less than 24 or evidence of ET or secondary
parkinsonism were excluded. The results of DAT-SPECT were compared with
criteria-based clinical diagnoses at a mean follow-up of 4.6 years. The clinical
diagnoses at baseline and follow-up were performed independently of DAT-SPECT
findings. Image analysis was performed by 2 nuclear medicine specialists blinded
to the clinical diagnosis. The study also included 37 age-matched healthy controls
who underwent DAT-SPECT imaging for evaluation of specificity. There was a
discrepancy between the reviewers in 10 (9.3\%) cases; these were reevaluated to
reach a consensus. Visual assessment in this enriched population had a sensitivity
of 94\% and specificity of 92\%, with 3 of 37 controls considered false positives and
10 of 171 patients considered false negatives at baseline. However, at the time of
reporting, it was not known whether the SWEDD were true false negatives or
misdiagnoses as PS.

A number of published studies and meta-analyses have not included an
independent reference standard of either blinded clinical diagnosis at follow-up or
postmortem analysis of substantia nigra neuron degeneration. When a reference
standard is not independent of the diagnostic test, it can result in an apparent
increase in the sensitivity and specificity of the test. Therefore, the diagnostic
accuracy reported in these studies must be interpreted with caution.

For example, in 2014 Brigo et al reported a meta-analysis of DAT-SPECT to
differentiate between PD and vascular or drug-induced parkinsonisms.\textsuperscript{11} The meta-
analysis included 5 studies with diagnoses confirmed by imaging. There were a
number of study limitations. Most notably, in 3 studies, it was not clear if the
diagnosis at follow-up (criterion standard) was made blinded to the results of DAT-
SPECT and could thus be considered an independent reference standard. Two
studies published in 2014 analyzed data from Kupsch et al (see Effect on Health
Outcomes section).\textsuperscript{12} The studies included 92 patients with clinically uncertain
parkinsonian syndromes (CUPS) at baseline who had confirmed clinical diagnosis
at 1 year. Bajaj et al assessed the effect of age, disease stage, and other clinical
and neurocognitive measures on the diagnostic performance of DAT-SPECT.\textsuperscript{13}
Hauser et al reported that the diagnostic accuracy of DAT-SPECT was higher than
clinical diagnosis at baseline. Both studies were biased because the clinical diagnosis at 1 year was influenced by the imaging results and cannot be considered an independent reference standard.

Other studies have provided limited information on diagnostic accuracy because they were not conducted in an appropriate population that included patients with clinically uncertain PD or ET. For example, a 2000 multicenter study by Benamer et al included 158 patients with an established clinical diagnosis of parkinsonism, 27 cases of definite ET, and 35 healthy volunteers. Striatal uptake of the DAT ligand was graded visually as normal or abnormal by an institutional reader blinded to the clinical data and a blinded consensus panel of 5 readers. The institutional reader scored 154 of 158 cases of parkinsonism as abnormal, all 27 cases of ET as normal, and 34 of 35 healthy volunteers as normal, resulting in sensitivity of 97% and specificity (for ET) of 100%. For the consensus blinded read, sensitivity and specificity were 95% and 93%, respectively. A limitation of this study is the population, which was not comprised of patients with atypical or clinically uncertain parkinsonism or ET.

In 2014, O’Brien et al published an industry-funded pooled analysis of 4 clinical studies submitted in support of the new drug application to the U.S. Food and Drug Administration (FDA). All studies assessed the sensitivity and specificity of DAT-SPECT to detect nigrostriatal cell loss in patients with signs and symptoms of movement disorders and/or dementia. The clinical diagnosis, determined at baseline or at 12, 24, or 36 months after imaging, was performed independently of DAT-SPECT results in 3 of the 4 studies. Study populations ranged from patients with uncertain clinical diagnosis to patients with established clinical diagnosis. Pooled analysis showed a sensitivity of 93.1% (range, 75.0%-96.5%) and a specificity of 91.1% (range, 83%-100%) in the intention-to-treat population of 726 patients. Interpretation of this study is limited by heterogeneity in the included studies. Only 2 studies included a population of patients with an uncertain diagnosis, one of which was an open-label phase 4 study where the clinical diagnosis was not independent of DAT-SPECT. Individual studies are described in greater detail in the Effect on Health Outcomes section.

Vlaar et al retrospectively studied the diagnostic value of DAT and postsynaptic dopamine receptor binding in 248 patients with unclassified PS in 2008. Two investigators established a clinical diagnosis according to generally accepted clinical criteria and were certain enough to make a final diagnosis from the clinical records or from follow-up in all but 25 of the cases. Of the 248 patients, 80 underwent DAT-SPECT alone, 38 underwent dopamine receptor SPECT, and 130 underwent both scans. Scans were analyzed by a nuclear medicine specialist blinded to the clinical diagnosis, with DAT ligand binding of 2 SDs above or below healthy controls considered abnormal. Using clinical diagnosis as the comparator, the odds ratio (OR) for DAT-SPECT to distinguish between PD and ET was 82; between PD and vascular parkinsonism, it was 61; between PD and drug-induced parkinsonism, it was 36; and between PD and atypical PS, it was 1. Because there were uncertain clinical diagnoses in only 25 patients, this does not appear to be an
appropriate patient population, the semiquantitative image analysis may not be representative, and the study was retrospective.

The diagnostic accuracy of DAT-SPECT can be compared with the diagnostic accuracy of clinical diagnosis. A longitudinal study by Adler et al found that, compared with neuropathologic findings of PD as the criterion standard, clinical diagnosis by a movement disorder specialist of possible PD (n=34) had only 26% accuracy. Clinical diagnosis by a movement disorder specialist of probable PD (n=97) on the first visit had 53% PPV in cases with a disease duration less than 5 years and 88% PPV in patients with disease duration of 5 years or more. Joutsa et al reported a retrospective study of the diagnostic accuracy of PD by general neurologists. Of 1362 cadavers examined post mortem, 122 cases were identified with a clinical and/or neuropathologic diagnosis of PD. The sensitivity of clinical diagnosis of PD was 89.2% and the specificity was 57.8% compared with postmortem neuropathologic diagnosis, indicating that 1 in 4 diagnoses by general neurologists was incorrect.

**Section Summary: Diagnostic Accuracy**
The literature on diagnostic performance includes meta-analyses of a number of small studies along with a large and well-conducted industry-sponsored study on the diagnostic accuracy of DAT-SPECT. In general, this evidence supports moderately high sensitivity and high specificity for the test. However, most studies had methodologic limitations, primarily the lack of a true criterion standard for the diagnosis of PS. In the highest quality study, in which the criterion standard was 36-month clinical diagnosis by a panel of independent experts, the sensitivity and specificity of testing were 78% and 97%, respectively. The PPV was 98.2% and the NPV was 66.2% in a population of patients with a prevalence of underlying PD of approximately 70%. This indicates that, in a population of patients with a high pretest likelihood of PD, a positive test may be useful in confirming PD, while a negative test is less useful in ruling out the disorder.

**Effect on Health Outcomes**
The most rigorous evaluation of the impact of a diagnostic test on clinical outcomes is an RCT that evaluates health outcomes in patients who received the new diagnostic test compared with patients who received the standard of care. In 2012 and 2013, Kupsch et al reported an industry-sponsored, open-label, multicenter randomized trial from 19 university hospital centers in Europe and the United States. The trial assessed the impact of DAT-SPECT on diagnosis, confidence of diagnosis, clinical management, health resource use, and safety in 273 patients with CUPS. Criteria of uncertainty included at least 1 of the following: only 1 of the 3 cardinal signs of parkinsonism; 2 signs without bradykinesia; atypical signs; signs of mild intensity; poor response to levodopa (L-dopa); and lack of disease progression. After the baseline visit and establishment of a clinical management plan, patients were randomized to DAT-SPECT or no imaging controls; the DAT-SPECT scans were visually classified as normal or abnormal by a nuclear medicine physician at each center who was blinded to clinical signs and/or symptoms. Patients were followed for 1 year (visits at 4
weeks, 12 weeks, 1 year) by neurologists with (n=12) or without (n=7) movement disorder specialization.

The primary outcome was the proportion of patients in the efficacy population (baseline and 12-week visits) who had 1 or more changes in clinical management. Significantly more patients in the DAT-SPECT group had at least 1 change in their clinical management plan by 12 weeks (50%) than in the control group (31%; p=0.002). This variance was due to a greater change in management by patients seeing movement disorder specialists (51% DAT-SPECT vs 28% controls, p<0.001). Medications were initiated in 29% of patients and withdrawn in 18% of patients after DAT-SPECT (patients could be counted in both categories). Changes included initiation of dopaminergic therapy or more aggressive dopaminergic therapy in patients with an abnormal scan, discontinuation of dopaminergic therapy, or initiation of tremor control drugs in patients with a normal scan, and unplanned diagnostic tests. For the general neurologists, the between-group variance in clinical management was not affected by the DAT-SPECT results (48% in DAT-SPECT vs 43% in controls; p=NS). Changes in diagnosis occurred in 45%, 46%, and 54% of DAT-SPECT patients by 4 weeks, 12 weeks, and 1 year, respectively (per protocol population) compared with a change in diagnosis in 9%, 12%, and 23% of control patients at the same time points (p<0.001 for all comparisons). Changes were in the direction of better agreement between the clinical diagnosis and imaging results. Clinicians had increased confidence in diagnoses at 4 weeks, 12 weeks, and 1 year in the DAT-SPECT group; the greatest change in confidence was for patients with an initially inconclusive diagnosis (62% vs 22% controls, p<0.001). There were no significant differences in quality of life or health resource utilization during the 1-year follow-up period. No serious adverse events occurred during the trial.

In 2004, Catafau and Tolosa reported a prospective multicenter trial on the impact of DAT-SPECT on the diagnosis and clinical management of 118 patients with CUPS, with 2-year follow-up reported in 2007. Criteria of uncertainty were assessed by referring neurologists and included at least 1 of the following: only 1 of the 3 cardinal signs of parkinsonism, with or without asymmetry; 2 signs without bradykinesia; atypical signs; signs of mild intensity; poor response to L-dopa; and lack of disease progression. Excluded were patients with an established clinical diagnosis and those where the uncertainty was between PD, multisystem atrophy, and progressive supranuclear palsy. Following clinical diagnosis into categories (presynaptic or nonpresynaptic PS, or inconclusive diagnosis), all patients underwent DAT-SPECT with visual assessment of images by a trained nuclear medicine physician. After reviewing the DAT-SPECT results, the neurologists again provided a diagnosis and recorded proposed changes in the planned management. At baseline, 67 patients were classified as suspected presynaptic PS, 26 as suspected nonpresynaptic PS, and 25 as inconclusive. DAT-SPECT results were inconsistent with the initial diagnosis in 36% of patients with suspected presynaptic PS (normal image) and 54% of patients with nonpresynaptic PS (abnormal image). After imaging, 19 (76%) inconclusive patients were reclassified and 16 (14%) of 118 patients were reclassified as inconclusive. Overall, imaging changed the diagnosis in 52% of patients and
changed management in 72% of cases. All patients with a final diagnosis of presynaptic PS had an abnormal image, whereas 94% of patients with nonpresynaptic PS had a normal scan.

At 2 years, 85 (72%) patients were available for follow-up. In 8 (9.4%) patients, the neurologist was unable to provide a definite diagnosis, and in 69 (90%) of the remaining 77 patients, the initial DAT-SPECT results agreed with the clinical diagnosis at follow-up. The rate of agreement was higher when the final diagnosis was presynaptic PS (97%) than when it was nonpresynaptic PS (77%). The rate of agreement between clinical diagnosis at baseline (before DAT-SPECT) and follow-up was 56%. This increased to 81% when the diagnosis after DAT-SPECT was compared with the diagnosis at follow-up. If clinical diagnosis at follow-up differed from that suggested by the initial scan (6/8 agreed to a second scan) or was inconclusive (n=8), a second DAT-SPECT scan was performed. There were discrepancies between the first and second scans in 6 of the 14 patients, and in 5 of these 6, the initial scan was considered abnormal. The second DAT-SPECT results helped to establish a diagnosis in 7 (87.5%) of 8 patients with a previously inconclusive diagnosis.

Bairactaris et al evaluated the impact of DAT-SPECT on diagnoses of patients with PS in a 2009 report. Sixty-one consecutive patients with an initial diagnosis of parkinsonism (n=40) or uncertain tremor disorder (n=21) by their treating community neurologist were reexamined by 2 neurologists blinded to the original diagnosis (overall agreement between blinded neurologists, 75.7%; κ=0.461). Patients then underwent DAT-SPECT imaging, which was evaluated by 2 masked independent and experienced nuclear medicine physicians using a semiquantitative approach and classified as normal or abnormal (κ=0.855). Based on DAT-SPECT imaging, the initial diagnosis was altered for 21 (34.4%) patients relative to the initial classification from the community neurologist and for 6 (9.8%) patients diagnosed at their center. All patients were reexamined by 2 neurologists at the center at 1-year follow-up and classified as having neurodegenerative or non-neurodegenerative disorders. With the final diagnosis as the reference standard, DAT-SPECT had a sensitivity of 95%, specificity of 82%, and PPVs and NPVs of 90%. Although this study was well-conducted, evaluation of DAT-SPECT scans by 2 experienced nuclear medicine physicians using a semiquantitative approach may not be representative of results obtained outside of the investigational setting. As noted by the authors, DAT-SPECT studies did not appear to add a great deal to the diagnosis made by an expert in movement disorders.

Additional retrospective studies have supported a change in diagnosis and increase in confidence in diagnosis following DAT-SPECT. Several tertiary referral centers have reported a change in diagnosis and management for a majority of patients with CUPS. Oravivattanakul et al reported on the concordance between pre-scan diagnosis and scan results in 175 CUPS patients who were seen by movement disorders neurologists. When essential/dystonic tremor was suspected, the scan was normal in 79%. DaTscan influenced medical treatment more when scans were abnormal than when normal. Only 4% of patients with
abnormal scans remained off medications, while 24% of patients with normal scans remained on medication.

Sadasivan and Friedman also reported on the clinical outcome of the change in management.26 Sixty-five CUPS patients were referred for DAT-SPECT over a 17-month period. Scans were abnormal in 22 patients, leading to a final diagnosis of PD in 22 patients and a change in management in 41 (63%) patients. Of the 41 patients with a change in management, 30 (73%) were clinically stable or improved at follow-up. This included 10 patients found to have drug-induced PD without any striatal neurodegeneration, leading to drug discontinuation or dose reduction.

Another study from a tertiary care center evaluated 83 scans ordered over a 2-year period with specific features that led the physician to question the diagnosis.25 The greatest impact was to differentiate ET from PD, with a change in diagnosis, management, or both in 72.2% of these patients. In a retrospective review of the effect of DAT-SPECT on diagnosis by referring physicians, Siefert and Weiner found that confidence in a diagnosis of PD or non-PD was significantly increased with abnormal scans, but not with normal scans.28 For many patients, the scan confirmed the diagnosis of PD, despite a poor response to medication and resulted in a change in medication.

A retrospective study from a European hospital imaging facility evaluated whether routine clinical requests for DAT-SPECT were appropriate or inappropriate and whether the results changed management.29 Appropriateness was determined by consensus of 2 movement disorders specialists, and a request was considered inappropriate if DAT-SPECT was unable to answer the question or if DAT-SPECT results would not change patient care. For example, a differential diagnosis between parkinsonian tremor and ET was considered appropriate, while evaluation of the severity of dopaminergic cell loss in already diagnosed PD was always considered to be inappropriate. Of 516 consecutive requests over an 8-year period, 37% were considered inappropriate. They included requests to assess the degree of dopaminergic denervation in already diagnosed patients (n=40) and confirmation of a clinically evident diagnosis (n=64). Scan requests by movement disorder specialists (79%) were considered appropriate more frequently than requests from other physicians (57%; p<0.01). A change in management was identified in 13% of patients with an inappropriate scan compared with 92% of the patients with an appropriate scan, and a change in management was more frequently observed if the scan was requested by movement disorders specialists (71%) than by other physicians (56%; p=0.01).

Other literature has shown that the level of DAT-SPECT binding does not predict disease severity or have prognostic value for the progression of motor symptoms in PD.30,31

**Section Summary: Effect on Health Outcomes**
Evidence on clinical utility includes a well-conducted RCT, a prospective multicenter trial, and several retrospective studies that have evaluated the effect
of DAT-SPECT on diagnosis and changes in treatment. These studies have reported that the use of this technology can change diagnoses in a minority of patients, provide greater confidence in the diagnosis by the treating clinician, and change treatment (eg, medication management). However, only 1 retrospective series indicated that these changes improve health outcomes. A limitation of this evidence is the lack of a criterion standard diagnosis to evaluate whether changes made were in the direction of more accurate diagnosis and more appropriate management. For example, the RCT showed that more patients evaluated with DAT-SPECT had changes in diagnosis and management than controls without imaging; however, no improvement in quality of life was observed by the 1-year follow-up.

**Clinically Uncertain Dementia With Lewy Bodies**

**Diagnostic Accuracy**
The largest study to evaluate DAT-SPECT for DLB is a 2007 prospective, investigator-initiated, industry-sponsored, multicenter study by McKeith et al, who assessed 326 patients with clinical diagnosis of probable (n=94) or possible (n=57) DLB or non-DLB (n=147). In 28 patients, no diagnosis was made. Diagnoses were established by a consensus panel of 3 clinicians without access to DAT-SPECT results; DAT-SPECT scans were assessed visually by 3 nuclear medicine physicians with expertise in DAT-SPECT imaging who were unaware of the clinical diagnosis. DAT-SPECT had a mean sensitivity of 77.7% for detecting clinical probable DLB, a specificity of 90.4% for excluding non-DLB dementia, a PPV of 82.4%, and an NPV of 87.5%. This study did not use long-term clinical follow-up as the standard.

A 2015 meta-analysis by Brigo et al evaluated the diagnostic accuracy of DAT-SPECT to distinguish between DLB and other dementias. Eight studies were included, of which 3 studies used histopathology as the reference standard. Studies that used clinical diagnosis as the reference standard showed diagnostic accuracy above 80% when using visual or semiquantitative analysis (see Table 1). The 2 studies using a histopathologic reference standard and visual analysis showed similar sensitivity (87%) and slightly higher specificity (92%) compared with studies that used clinical diagnosis as the reference standard. The single study that used semiquantitative analysis with histopathology as a reference standard correctly identified the 15 patients with DLB (100% sensitivity) and had 90% specificity in the identification of the 8 patients with non-DLB dementia. Because only 23 patients enrolled in this study, additional research is needed to corroborate these results.

**Table 1. Accuracy of DAT-SPECT in the Differential Diagnosis of DLB vs Non-DLB Dementia (Brigo et al, 2015)**

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Reference Standard</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>No. of Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>Clinical diagnosis</td>
<td>87%</td>
<td>84%</td>
<td>6</td>
</tr>
<tr>
<td>Semiquantitative</td>
<td>Clinical diagnosis</td>
<td>79%</td>
<td>86%</td>
<td>4</td>
</tr>
<tr>
<td>Visual</td>
<td>Histopathology</td>
<td>87%</td>
<td>92%</td>
<td>2</td>
</tr>
<tr>
<td>Semiquantitative</td>
<td>Histopathology</td>
<td>100%</td>
<td>90%</td>
<td>1</td>
</tr>
</tbody>
</table>
Several studies have followed patients with inconsistent results from DAT-SPECT and clinical diagnosis. In 2013, Siepel et al reported a longitudinal study of patients who had inconsistent clinical criteria for DLB and DAT-SPECT results at baseline. Fifty patients were evaluated with clinical criteria and DAT-SPECT results and followed for 2 to 5 years. Twenty-eight patients met clinical criteria for DLB or non-DLB; the remaining patients were clinically inconclusive and not included in the analysis. For 18 patients the DAT-SPECT scan and clinical criteria were concordant. Blinded analysis showed 7 patients who had an abnormal scan but did not initially meet the clinical criteria for DLB developed typical clinical features over follow-up. Three patients who met clinical criteria for DLB but had a normal DAT-SPECT at baseline continued to meet clinical criteria for DLB over follow-up, indicating a false-negative scan (SWEDD) in 6% of patients. Van der Zande et al (2016) reported on 7 (10.4%) of 67 patients who were clinically diagnosed with DLB but had normal scans. In 5 of the 7, second DAT-SPECT scans (average 1.5 years later) were abnormal. There were no differences in baseline clinical characteristics, but patients with initially normal scans were less severely affected after 1 year. These studies evaluated small numbers of subjects and lacked autopsy findings to confirm the diagnosis.

**Effect on Health Outcomes**

In 2015, Walker et al reported an industry-funded RCT to determine whether DAT-SPECT would change diagnosis and provide more confidence in the diagnosis of patients with probable DLB or non-DLB dementia. Patients were included in the trial if they were diagnosed as possible DBL by local neurologists or geriatric psychiatrists, had dementia, and either 1 core feature or 1 or more suggestive features of DLB. Excluded were patients with: an established clinical diagnosis of probable DLB or non-DLB dementia; Parkinson features for more than 1 year; significant vascular pathology; severe mental or physical illness that could account for dementia; or a medication known to influence DAT-SPECT binding (including amphetamine, benatropine, bupropion, cocaine, mazindol, methylphenidate, phentermine, and sertraline). A total of 187 patients were randomized 2:1 to have DAT-SPECT scans or clinical diagnosis alone. Onsite cliniciansrecorded DLB features and rated their confidence in diagnosis using a visual analog scale (VAS; range, 0-100). The readers, who had variable expertise, rated 57% of scans as normal and 43% as abnormal. At 8- and 24-week follow-ups, the onsite clinicians were more likely to change the diagnosis in patients who had imaging compared with control patients (eg, 71% revised vs 16%, p<0.001) and were more confident in their diagnosis (p<0.001). Clinicians were also more likely to change the diagnosis if the scan was abnormal (82%) than if it was normal (46%).

Kemp et al retrospectively analyzed the impact of DAT-SPECT on the clinical diagnosis and subsequent management of 80 consecutive patients with possible DLB. Patients had been referred for imaging with suspected DLB by 33 specialists in geriatric psychiatry working at 11 memory clinics in the U.K. All DAT-SPECT scans were interpreted visually by a single observer in conjunction with the clinical
referral details and any other relevant imaging. DAT-SPECT imaging results were abnormal in 20 (25%) and normal in 60 (75%) patients. Of the 20 patients with an abnormal scan, 18 (90%) had a postscan working clinical diagnosis of DLB, 1 (5%) had a diagnosis of vascular dementia, and 1 (5%) had no recorded outcome. Fifty-eight (97%) of the 60 patients with a normal DAT-SPECT scan had an alternative clinical diagnosis. Subsequent to DAT-SPECT, scan findings and diagnoses were discussed with patients and/or their caregivers in 94% of cases. Pharmacologic management affecting antipsychotic, dopaminergic, or cholinergic medication was changed in about half of the patients after the scan, although many (irrespective of the imaging results) were in the earliest phase of their disease process and did not require immediate treatment for symptoms. In addition, the small numbers did not permit substantive conclusions about changes in specific therapies.

Section Summary: Dementia With Lewy Bodies
A 2015 meta-analysis evaluated the diagnostic accuracy of DAT-SPECT to distinguish between DLB and non-DLB dementia. However, clinical diagnosis as a reference standard may be flawed, and few patients have been studied to date who have histopathology as the reference standard. Evidence of clinical utility includes 1 RCT that evaluated changes in diagnosis and confidence in diagnosis following DAT-SPECT imaging. This trial indicated that DAT-SPECT can influence diagnosis of DLB, particularly when the scan is abnormal. It cannot be determined from this trial whether the revised diagnosis was more accurate or resulted in a beneficial change in patient management. Longer follow-up of patients in this trial may lead to greater certainty about the effect of this technology on health outcomes.

Ongoing and Unpublished Clinical Trials
Some currently unpublished trials that might influence this review are listed in Table 2.

Table 2. Summary of Key Trials

<table>
<thead>
<tr>
<th>NCT No.</th>
<th>Trial Name</th>
<th>Planned Enrollment</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ongoing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCT01453127</td>
<td>DaTSCAN Imaging in Aging and Neurodegenerative Disease</td>
<td>130</td>
<td>Nov 2016</td>
</tr>
<tr>
<td>NCT01141023</td>
<td>The Parkinson's Progression Markers Initiative (PPMI)</td>
<td>680</td>
<td>Dec 2017</td>
</tr>
<tr>
<td>NCT01950468a</td>
<td>Evaluation of the Diagnostic Efficacy and Safety of [123I]NAV5001 as an Imaging Agent to Aid in the Diagnosis of Parkinsonian Syndromes</td>
<td>275</td>
<td>Mar 2018</td>
</tr>
<tr>
<td>NCT01767818</td>
<td>Longitudinal, Single-center Prospective Study to Assess Progression of Clinical Features and Biologic Markers of Parkinson's Disease Subjects of Varying Levels of Disease Severity</td>
<td>240</td>
<td>Sep 2019</td>
</tr>
</tbody>
</table>

NCT: national clinical trial.
a Denotes industry-sponsored or cosponsored trial.
Summary of Evidence
For individuals who have clinically uncertain Parkinson disease who receive dopamine transporter imaging with single-photon emission computed tomography (DAT-SPECT), the evidence includes a number of studies from Europe, where a dopamine transporter (DAT) ligand has been available for over a decade. Relevant outcomes are test accuracy, symptoms, functional outcomes, and medication use. In terms of technical performance, the DAT ligand is specific for the striatal DAT, and studies have indicated reliability in assessment of the images when performed by experienced readers. Studies of diagnostic accuracy have reported good specificity for confirming nigrostriatal degeneration, with less sensitivity for ruling out disease; these findings are dependent, however, on a reference standard (clinical diagnosis), which may be flawed, and it is unknown whether DAT-SPECT would show greater sensitivity than the criterion standard (histopathologic diagnosis). Evidence on clinical utility includes a randomized controlled trial (RCT) that showed more patients evaluated with DAT-SPECT had changes in diagnosis and management than controls without imaging; however, there is limited evidence to evaluate whether these changes improve health outcomes. The evidence is insufficient to determine the effects of the technology on health outcomes.

For individuals who have clinically uncertain dementia with DLB who receive DAT-SPECT, the evidence includes studies on diagnostic accuracy and its effect on diagnosis and confidence in diagnosis. Relevant outcomes are test accuracy, symptoms, functional outcomes, and medication use. For discriminating between DLB and Alzheimer disease, the sensitivity and specificity of DAT-SPECT is somewhat lower than for parkinsonian syndromes, although the comparison standard used in the available studies may be flawed. Few patients have been evaluated with histopathology as the reference standard. Evidence on clinical utility includes an RCT that showed DAT-SPECT can influence the diagnosis of DLB, particularly when the scan is abnormal. It cannot be determined from this study whether the revised diagnosis was more accurate or resulted in a beneficial change in patient management. The evidence is insufficient to determine the effects of the technology on health outcomes.

SUPPLEMENTAL INFORMATION

Clinical Input Received Through Academic Medical Centers and Specialty Medical Societies
While the various academic medical centers and specialty medical societies may collaborate with and make recommendations during this process, through the provision of appropriate reviewers, input received does not represent an endorsement or position statement by the academic medical centers or specialty medical societies, unless otherwise noted.

2015 Input
In response to requests, input was received from 1 physician specialty society and 3 academic medical centers (4 reviewers) while this policy was under review in
2015. Input on whether DAT-SPECT is considered to be medically necessary in the assessment of clinically uncertain parkinsonian syndrome or to differentiate between clinically uncertain parkinsonian syndromes and essential tremor was mixed. Most respondents did not consider DAT-SPECT to be medically necessary to differentiate between DLB and Alzheimer disease.

2012 Input
In response to requests, input was received from and 3 physician specialty societies and 3 academic medical centers (6 reviewers) while this policy was under review in 2012. Input on the medical necessity of DAT-SPECT was mixed.

Practice Guidelines and Position Statements

American College of Radiology
The American College of Radiology (ACR) published appropriateness criteria for dementia and movement disorders, last reviewed in 2015.\textsuperscript{38} ACR has stated that the diagnosis of idiopathic Parkinson disease (PD) is usually based on patient history and physical examination alone and that, when clinical signs and symptoms and response to medication are typical of PD, neuroimaging is not required. In patients with unusual clinical features, incomplete or uncertain medication responsiveness, or clinical diagnostic uncertainty, imaging to exclude alternative pathologies may be indicated. ACR has stated that positron emission tomography (PET) and SPECT tracer studies exploring the presynaptic nigrostriatal terminal function and the postsynaptic dopamine receptors have been unable to reliably classify the various parkinsonian syndromes and may not reliably measure disease progression. Use of DAT-SPECT was rated 5 (may be appropriate) to evaluate suspected DLB and rated 3 (usually not appropriate) to evaluate PD with either typical or atypical clinical features.

A 2015 review of the evidence underlying these recommendations stated:

“\textit{F} florbetapir has been shown to be well tolerated, to distinguish patients with AD [Alzheimer disease] from healthy controls, and to correlate with amyloid load on pathology at autopsy. Amyloid PET, however, may be positive in cognitively normal subjects who do not develop AD and in patients with other forms of non-AD dementia. Although negative results on an amyloid PET scan likely mean a low probability of AD, the patient may still harbor a non-AD neurodegenerative condition.”\textsuperscript{39}

American Academy of Neurology
The 2006 practice parameters (reaffirmed in July 2013) from the American Academy of Neurology stated that β-CIT and IBZM (iodobenzamide) SPECT are possibly useful in distinguishing PD from essential tremor (ET; 5 class III studies).\textsuperscript{40} There was insufficient evidence to determine if these modalities are useful in distinguishing PD from other forms of parkinsonism.
Society of Nuclear Medicine and Molecular Imaging
The international Society of Nuclear Medicine, now called the Society of Nuclear Medicine and Molecular Imaging, provided a practice guideline for DAT imaging with SPECT in 2011. The guideline stated that the main indication for DAT-SPECT is striatal DAT visualization in the evaluation of adult patients with suspected PS to help differentiate ET from tremor due to presynaptic PS (PD, multiple-system atrophy, progressive supranuclear palsy). Other indications are the early diagnosis of presynaptic PS, differentiation of presynaptic PS from parkinsonism without presynaptic dopaminergic loss (eg, drug-induced parkinsonism, psychogenic parkinsonism), and differentiation of DLB from AD. The guidance stated that visual interpretation of the scan is usually sufficient for clinical evaluation, where the striatal shape, extent, symmetry, and intensity differentiate normal from abnormal. For semiquantitative analysis, each site should establish its own reference range by scanning a population of healthy controls or by calibrating its procedure with another center that has a reference database.

Movement Disorders Society
The Movement Disorder Society’s (MDS) diagnostic criteria for PD from 2015 are intended for use in clinical research but may be used to guide clinical diagnosis. MDS considers clinical expert opinion to be the criterion standard to diagnose PD and that diagnoses are usually made clinically without need for ancillary diagnostic testing. Methods that may become available as knowledge advances are diagnostic biochemical markers, anatomical neuroimaging, and methods to detect alpha-synuclein deposition. MDS noted that, although dopaminergic neuroimaging can help to distinguish parkinsonism from PD mimics like ET, “it does not qualify as a criterion for the differentiation of PD from other parkinsonian conditions like atypical parkinsonian syndromes.”

European Federation of Neurological Societies and Movement Disorder Society
The European Federation of Neurological Societies and Movement Disorder Society–European Section (EFNS/MDS-ES) published recommendations for the diagnosis of PD in 2013. EFNS/MDS-ES provided a level A recommendation for the use of DAT-SPECT in the differential diagnosis between degenerative parkinsonism and ET. The guidelines specified that DAT-SPECT is indicated in the presence of significant diagnostic uncertainty and particularly in patients presenting atypical tremor manifestations.

European Association of Nuclear Medicine
The European Association of Nuclear Medicine’s neuroimaging committee published updated guidelines on procedures for DAT-SPECT in 2010, based on the individual experience of experts in European countries. The guidelines stated that iodine 123 N-(3-fluoropropyl)-2β-carbomethoxy-3β-(4-iodophenyl)nortropane (123I-FP-CIT) imaging is indicated for detecting loss of functional dopaminergic neuron terminals in the striatum of patients with clinically uncertain parkinsonian syndrome and for the differentiation of DLB from other dementias. Other indications are the early diagnosis of neurodegenerative parkinsonism, assessment of disease severity, and differentiation of presynaptic parkinsonism from other
forms of parkinsonism (eg, neuroleptic-induced parkinsonism). The guidelines stated that, in addition to visual interpretation, semiquantitative analysis is recommended to objectively assess striatal DAT binding. Issues requiring further clarification include the assessment of disease progression and effects of treatments and methods for operator-independent definition of region of interest.

**National Institute for Health and Clinical Evidence**
The U.K.’s National Institute for Health and Clinical Evidence (NICE) published a clinical guideline on the diagnosis and management of PD in 2006. The guideline stated that $^{123}$I-FP-CIT SPECT should be considered for people with tremor where ET cannot be clinically differentiated from parkinsonism (based on studies with level of evidence 1a or 1b) and that $^{123}$I-FP-CIT SPECT should be available to specialists with expertise in its use and interpretation (based on level of evidence IV, expert opinion). An update on this guideline is in progress, with stakeholders reviewing the new draft in October/November 2016. The expected release of the new guideline is April 2017.

NICE also updated its clinical guideline on dementia in May 2016. The guideline recommends that $^{123}$I-FP-CIT SPECT should be used to help establish the diagnosis in those with suspected DLB if the diagnosis is in doubt.

**U.S. Preventive Services Task Force Recommendations**
Not applicable.

**Medicare National Coverage**
There is no national coverage determination (NCD). In the absence of an NCD, coverage decisions are left to the discretion of local Medicare carriers.

References:


Billing Coding/Physician Documentation Information
78607  Brain imaging, tomographic (SPECT)
A9584  Iodine I-123 ioflupane, diagnostic, per study dose, up to 5 millicuries
ICD-10 Codes

G20  Parkinson's disease (includes primary parkinsonism)
G21.0-  Secondary parkinsonism code range
G21.9
G31.83  Dementia with Lewy bodies

Additional Policy Key Words
N/A

Policy Implementation/Update Information

9/1/15  New policy, considered investigational.
9/1/16  No policy statement changes.
9/1/17  No policy statement changes.

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