Medical Policy

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(See policy history boxes for previous effective dates)

Title: Magnetic Resonance Neurography (MRN)

Description/Background

Magnetic resonance (MR) imaging of the peripheral nervous system, also known as magnetic resonance neurography (MR Neurography or MRN), is a special type of magnetic resonance imaging used to visualize peripheral nerves. Specially designed phased-array surface coils provide superior resolution of small structures so that normal-sized nerves can be distinguished from surrounding soft tissues, and the internal structure of the nerves can be visualized. The procedure is purported to show high-resolution images of peripheral nerves in order to diagnose peripheral nerve disorders. Proposed uses for MRN include defining the specific location of nerve entrapment (e.g., radiculopathy) and compression as well as diagnosing malignant infiltration and invasion. MRN may detect secondary findings of muscle denervation.

Nerve injuries secondary to either compression or traumatic accidents are generally diagnosed and managed without imaging the nerves directly. Standard magnetic resonance imaging (MRI) can occasionally help to visualize the nerves, but historically this method of imaging has proven to be so unreliable that MRI has never been a major diagnostic tool in the management of these patients. MRN has been developed to improve the use of magnetic resonance imaging using special software and hardware.

Proponents of MRN state that MR Neurography may be useful for both preoperative diagnosis and presurgical planning. Direct nerve imaging with MR Neurography has the potential to demonstrate nerve continuity, distinguish intraneural from perineural masses, and localize nerve compressions prior to surgical exploration. Proponents also believe that the technology can add clinically useful diagnostic information in many situations where neurological examinations, electrodiagnostic tests, and existing image techniques are inconclusive. Preliminary studies suggest a wide range of indications, including carpal tunnel syndrome, cubital tunnel syndrome or ulnar nerve entrapment at the elbow, cervical radiculopathy, brachial plexopathy or thoracic outlet syndrome, lumbosacral plexopathy, sciatica, traumatic peripheral nerve injuries, peripheral

nerve tumors and cysts, or any other condition thought to be due to nerve compression or impingement.

MR Neurography of the spinal and peripheral nerves has been proposed as an additional diagnostic tool for diagnosing pathology related to nerves. The following indications have been proposed for MR Neurography:

- Prediction of resectability of peripheral nerve lesions and the need for intraoperative monitoring;
- Identification of nerves enhancing the safety of image-guided procedures;
- Assistance in surgical planning by clarifying intraneural versus perineural location of lesion;
- Assessment of nerve continuity immediately after injury.

MRN has been used to supplement diagnostic evaluations following electromyography (EMG) and nerve conduction studies for patients who are suspected of having peripheral nerve tumors, chronic compression syndromes, nerve injury following trauma, post-irradiation neuritis and nerve lesions. MRN has the ability to generate high-resolution longitudinal and cross-sectional images of major peripheral nerves. It appears to be a promising technique, but has not been studied in large populations of patients. Large-scale controlled studies are needed to determine its efficacy in managing conditions such as neurofibromas as well as its ability to distinguish benign from malignant lesions.

Regulatory Status:

Magnetic resonance imaging equipment has been approved by the FDA for a number of years. MR Neurography uses FDA-approved MRI machines that are equipped with specialized hardware and software need to image the nerve structures.

Medical Policy Statement

Magnetic resonance neurography is experimental/investigational. Its use has not been scientifically demonstrated to improve patient clinical outcomes.

Inclusionary and Exclusionary Guidelines

N/A

CPT/HCPCS Level II Codes *(Note: The inclusion of a code in this list is not a guarantee of coverage. Please refer to the medical policy statement to determine the status of a given procedure)*

Established codes:

N/A

Other codes (investigational, not medically necessary, etc.):

76498

Rationale

In 2005, Filler et al published a non-randomized, controlled trial of 239 patients with a diagnosis of sciatica of unknown etiology for which standard diagnosis and treatment had failed.[5] These individuals, all of whom had similar symptoms, underwent conventional MRI and MR neurography followed by MR-guided Marcaine injection into the piriformis muscle. The diagnostic efficacy revealed that piriformis muscle asymmetry and sciatic nerve hyperintensity at the sciatic notch exhibited a 93% specificity and 64% sensitivity in distinguishing individuals from those without piriformis syndrome. This was a single study regarding a single anatomic area and diagnostic issue, and results cannot be generalized to other uses for MR Neurography.

In 2009, Zhang et al reported on a prospective observational study of patients with sciatica. They investigated the effectiveness of 3-dimensional high-spatial resolution diffusion-weighted MR Neurography based on steady state free precession (3-dimensional diffusion-weighted steady-state free precession [DW-SSFP]) in the diagnosis of sciatica.[11] The abstract of the study states:

"The 3-dimensional DW-SSFP sequence was performed on 137 patients with sciatica and 32 patients in control group. The post processing techniques were used to generate images of lumbosacral plexus and sciatic nerve, and the images acquired were assessed based on the presence or absence of nerve abnormality. The certainty of identifying the lumbosacral plexus and main branches from all cases was determined in each of the reconstruction planes for each case individually and assessed by using a 3-score scale.

The procedure was successfully performed in all of the patients. The sciatic nerve and its main branches were differentiated and a clear picture was obtained in all subjects. Compared with the control group, the presence of nerve root compression or increased T2 signal intensity changes can be observed in all patients. The mean score of certainty of identifying the sciatic nerve and main branches was 1.76 +/- 0.4, which indicate that the sciatic nerve and main branches can be identified with certainty. The conclusion of the study was that the 3-dimensional DW-SSFP MRI with high spatial and sufficient contrast is an excellent technique to define the nature of sciatica and assists in prognostication and possibly in management."

In 2010, Du et al analyzed the role of MRN in evaluation of spinal and peripheral nerve lesions. Imaging studies, medical records, and results of EMG/nerve conduction studies (NCS) (if performed) were analyzed retrospectively in a consecutive series of 191 patients who underwent MR Neurography for spinal and peripheral nerve disorders.[15] Of the 91 patients (47.6%) that underwent EMG/NCS studies and MRN, MR Neurography provided the same or additional diagnostic information in 32% and 45% of patients, respectively.

The authors concluded that "Magnetic resonance neurography is a valuable adjunct to conventional MR imaging and EMG/NCS in the evaluation and localization of nerve root, brachial plexus, and peripheral nerve lesions. The authors found that MRN is indicated in patients: 1) in whom EMG and traditional MR imaging are inconclusive; 2) who present with brachial plexopathy who have previously received radiation therapy to the brachial plexus region; 3) who present with brachial plexopathy and have systemic tumors; and 4) in patients under consideration for surgery for peripheral nerve lesions or after trauma. Magnetic

resonance neurography is limited by the size of the nerve trunk imaged and the timing of the study."

They also concluded that the utility of MRN is limited if the time from onset of symptoms is greater than one year, and also because of the possibility of imaging the wrong location along the course of the peripheral nerve.

In 2010, Vargas et al authored an article that discussed several new imaging techniques in addition to conventional 2D MR sequences in order to study the brachial plexus.[16] Several new techniques are used in addition to conventional 2-D MR sequences to study the brachial plexus: the 3-D STIR SPACE sequence, 3-D heavily T2w MR myelography sequences (balanced SSFP=CISS 3-D, True FISP 3-D, bFFE and FIESTA), and the diffusion-weighted (DW) neurography sequence with fiber tracking reconstruction (tractography). Highlights include:

- The 3-D STIR sequence offers complete anatomical coverage of the brachial plexus and the ability to slice through the volume helps to analyze fiber course modification and structure alteration. It allows precise assessment of distortion, compression and interruption of post-ganglionic nerve fibers thanks to the capability of performing maximum intensity projections (MIP) and multi-planar reconstructions (MPRs).
- The CISS 3D, b-SSFP sequences allow good visualization of nerve roots within the spinal canal and may be used for MR myelography in traumatic plexus injuries.
- The DW neurography sequence with tractography is still a work in progress, able to demonstrate nerves tracts, their structure alteration or deformation due to pathologic processes surrounding or located along the post-ganglionic brachial plexus. It may become a precise tool for the understanding of the underlying molecular pathophysiologic mechanisms in diseases affecting the brachial plexus and may play a role for surgical planning procedures in the near future.

In a 2011 article, Eguchi et al stated that DW imaging (DWI) could provide valuable structural information that may be useful for evaluating pathological changes of the lumbar nerve root.[3] They stated that diffusion-weighted MR neurography has recently been introduced as an alternative way to visualize nerves, but to date, quantitative DWI and MR neurography have not been applied to evaluate the pathology of lumbar nerve roots.

According to the abstract of their article, the authors visualized lumbar nerve roots and analyzed their morphology by MR neurography, and measured the apparent diffusion coefficient (ADC) of lumbar nerve roots compressed by herniated disks using 1.5-T MR imaging. Ten consecutive patients (median age of 48.0 and range of 20 to 72 years) with mono-radicular symptoms caused by a lumbar herniated disk and 14 healthy volunteers were studied. Regions of interests (ROIs) were placed on the lumbar roots at dorsal root ganglia (DRG) and distal spinal nerves on DWI to quantify mean ADC values. The spinal nerve roots were also visualized by MR neurography. In the patients, mean ADC values were significantly greater in the compressed DRG and distal spinal nerves than in intact nerves. Magnetic resonance neurography also showed abnormalities such as nerve swelling at and below the compression in the symptomatic nerve root. Increased ADC values were considered to be because of edema and Wallerian degeneration of compressed nerve roots. Their conclusion was that DWI is a potential tool for analysis of the pathophysiology of lumbar nerve roots compressed by herniated disks.

In 2011, Merlini et al performed a study to assess the feasibility of MRN in children as well as the potential roles of diffusion-weighted imaging (DWI) and fiber-tracking (FT) techniques.[12] The abstract of the article states that "Five pediatric patients (age range: 6-12 years) underwent magnetic resonance imaging (MRI) for various clinical indications: neurogenic bladder (case 1); persistent hand pain following minor trauma (case 2); progressive atrophy of the lower left extremity muscles (case 3); bilateral hip pain (case 4); and palpable left supraclavicular mass (case 5). All studies were performed using a 1.5-T Avanto MRI scanner (Siemens, Erlangen, Germany). The protocol included 3D T2-weighted STIR and SPACE imaging, T1-weighted fat-saturation post-gadolinium imaging and diffusion tensor imaging (DTI) with tractography. ADC (N×10 (-3) mm (2)/s) and FA values were calculated from regions of interest (ROIs) centered on the nerves. Nerve-fiber tracks were calculated using a fourth order Runge-Kutta algorithm (NeuroD software). Results: MR neurography allowed satisfactory visualization of all neural structures, and FA and ADC measurements were feasible. The final diagnoses were Tarlov cysts, median-nerve compression, sciatic perineurioma, Charcot-Marie Tooth disease and plexiform neurofibroma in a patient with NR-1."

The authors concluded that "MR neurography is feasible in pediatric patients. However a considerable amount of work has yet to be done to establish its role in the clinical management of the wide range of peripheral nerve diseases."

Chung et al (2014) noted that magnetic resonance neurography (MRN) has utility in the diagnosis of many focal peripheral nerve lesions.[23] The authors stated that when combined with history, examination, electrophysiology, and laboratory data, future advancements in high-field MRN may play an increasingly important role in the evaluation of patients with peripheral neuropathy.

Thawait et al (2012) stated that MRN is a specialized technique that is rapidly becoming part of the diagnostic algorithm of peripheral nerve pathology.[9] However, in order for this modality to be considered appropriate, its value compared with current methods of diagnosis should be established. Therefore, radiologists involved in MRN research should use appropriate methodology to evaluate MRN's effectiveness with a multi-disciplinary approach.

Yoshida et al (2015) noted that there have been no reports of the use of 3-Tesla MRN (3T MRN) to characterize cervical radiculopathy. In particular, there are no reports of MRN of brachial plexus involvement in patients with cervical radiculopathy.[18] These investigators reviewed retrospectively 12 consecutive patients with cervical radiculopathy who underwent 3T MRN. The median age was 54.5 years; 11 of 12 patients were men. The distribution of nerve-root signal abnormality was correlated with intervertebral foraminal stenosis and the presence of muscles that exhibited weakness and/or signs of denervation on EMG. Abnormalities in MRN were found to extend into the distal part of the brachial plexus in 10 patients. The authors concluded that the findings of this study demonstrated that MRN is potentially useful for diagnosis in patients with suspected cervical radiculopathy. Moreover, they stated that the finding of brachial plexus involvement on MRN may indicate a possible pathophysiological relationship between cervical radiculopathy and brachial plexopathy.

In an observational study, Quinn and colleagues (2015) demonstrated use of MRN to visualize the course of the lumbar plexus at the L4 to L5 disc space.[17] Consecutive lumbar plexus MR neurograms (n = 35 patients, 70 sides) were studied. Scans were obtained on a Siemens 3T Skyra magnetic resonance imaging scanner. T1- and T2-color-coded fusion maps were

generated along with 3-D models of the lumbosacral plexus with attention to the L4 to L5 interspace. The position of the plexus and the shape of the psoas muscle at the L4 to L5 interspace were evaluated and recorded. Direct imaging of the lumbar plexus using MRN revealed a substantial variability in the position of the lumbar plexus relative to the L4 to L5 disc space. The left-side plexus was identified in zone 2 (5.7%), zone 3 (54.3%), and zone 4 (40%) (p = 0.0014); on the right, zone 2 (8.6%), zone 3 (42.9%) or zone 4 (45.7%), and zone 5 (2.9%) (p = 0.01). Right-left symmetry was found in 18 of 35 subjects (51.4%) (p = 0.865). There was no association between the position of the plexus and the shape of the overlying psoas muscle identified. In patients with an elevated psoas (n = 12), the lumbar plexus was identified in zone 3 in 75% and 66% (left and right) compared with patients without psoas elevation (n = 23), 30.4% and 43.5% (left and right). The authors concluded that the course of the lumbosacral plexus traversing the L4 to L5 disc space may be more variable than has been suggested by previous studies. They stated that MRN may provide a more reliable means of pre-operatively identifying the plexus when compared with current methods. These findings need to be validated by well-designed studies.

The current National Guideline Clearinghouse Guideline Summary NGC-8517 for Low Back – Lumbar and Thoracic (Acute and Chronic) lists magnetic resonance (MR) neurography as a procedure that is currently under study and not specifically recommended.[6]

The American College of Radiology's Appropriateness Criteria® on "Plexopathy" (2012) stated that "Magnetic resonance neurography, diffusion tensor imaging (DTI), and tractography are exciting developments currently under investigation."[1]

Menezes et al (2015) examined the use of DW-MRN in visualizing the lumbar plexus during pre-operative planning of lateral transpsoas surgery.[13] A total of 94 (188 lumbar plexuses) spine patients underwent a DW-MR examination of the lumbar plexus in relation to the L3 to L4 and L4 to L5 disc spaces and superior third of the L5 vertebral body. Images were reconstructed in the axial plane using high-resolution Maximum Intensity projection (MIP) overlay templates at the disc space and L3 to L4 and L4 to L5 interspaces; 10 and 22 mm MIP templates were chosen to mimic the working zone of standard lateral access retractors. The positions of the L4 nerve root and femoral nerve were analyzed relative to the L4 to L5 disc in axial and sagittal planes. Third-party radiologists and a senior spine surgeon performed the evaluations, with inter- and intra-observer testing performed. In all subjects, the plexus was successfully mapped. At L3 to L4, in all but 1 case, the components of the plexus (except the genito-femoral nerve) were located in the most posterior quadrant (zone IV). The L3 and L4 roots coalesced into the femoral nerve below the L4 to L5 disc space in all subjects. Side-to-side variation was noted, with the plexus occurring in zone IV in 86.2% right and only 78.7% of left sides. At the superior third of L5, the plexus was found in zone III in 27.7% of right and 36.2% of left sides; and in zone II in 4.3%, right and 2.1% left sides. Significant inter- and intra-observer agreement was found. The authors concluded that by providing the surgeon with a pre-operative roadmap of the lumbar plexus, DW-MRN might improve the safety profile of lateral access procedures. These findings need to be validated by well-designed studies.

Ishikawa et al (2016) used magnetic resonance imaging to visualize peripheral nerves in patients with chronic inflammatory demyelinating polyneuropathy (CIDP).[14] Thirteen patients with CIDP and 12 healthy volunteers were enrolled. Whole body MR neurography based on diffusion-weighted whole body imaging with background body signal suppression (DWIBS) was performed. Peripheral nerve volumes were calculated from serial axial MR images. The

peripheral nervous system was visualized with 3-dimensional reconstruction. Volumes ranged from 8.7 to 49.5 $cm^3/^2$ in the brachial plexus and nerve roots and from 10.2 to 53.5 $cm^3/^2$ in the lumbar plexus and nerve roots. Patients with CIDP had significantly larger volumes than controls ($P<0.05$), and volume was positively correlated with disease duration. The authors concluded that MR Neurography and the measurement of peripheral nerve volume might be useful for diagnosing and assessing CIDP.

Bao and colleagues (2017) examined the feasibility of DW-MRN in the visualization of extremity nerves in the wrist and palm.[19] A total of 32 volunteers and 21 patients underwent imaging of the wrist and palm on a 3T MR scanner. In all subjects, 2 radiologists evaluated the image quality on DW-MRN using a 4-point grading scale. Kappa statistics were obtained for inter-observer performance. In volunteers, the Chi-squared test was used to assess the differences in nerve visualization on DW-MRN and axial fat-suppressed proton density weighted imaging (FS-PDWI). In volunteers, the mean image quality scores for the median nerve (MN) and ulnar nerve (UN) were 3.71 ± 0.46 and 3.23 ± 0.67 for observer 1, and 3.70 ± 0.46 and 3.22 ± 0.71 for observer 2, respectively. The inter-observer agreement was excellent ($k = 0.843$) and good ($k = 0.788$), respectively. DW-MRN provided significantly improved visualizations of the 2nd and the 3rd common palmar digital nerves and 3 branches of UN compared with FS-PDWI ($p < 0.05$). In patients, the mean image quality scores for the 2 observers were 3.24 ± 0.62 and 3.10 ± 0.83, inter-observer performance was excellent ($k = 0.842$). The authors concluded that DW-MRN is feasible for improving visualization of extremity nerves and their lesions in the wrist and palm with adequate image quality, thereby providing a supplementary method to conventional MR imaging. Well-designed studies are needed to ascertain the safety and effectiveness of DW-MRN in the evaluation of median and ulnar nerves in the wrist and palm.

Yamashita and associates (2017) evaluated the potential of readout-segmented echo-planar DW-MRN (RS-EPI DW-MRN) for the selective visualization of pelvic splanchnic nerve and pelvic plexus in healthy male volunteers.[20] Institutional review board approval and written informed consent were obtained; RS-EPI DW-MRN images were acquired from 13 healthy male volunteers aged 25 to 48 years between September 2013 and December 2013. For RS-EPI DW-MRN, the following parameters were used: spatial resolution, 1.1×1.1×2.5 mm; b-value, 250 s/mm^2; number of readout-segments, 7; and acquisition time, 7 minutes 45 seconds. For qualitative assessment, 2 abdominal radiologists independently evaluated the visibility of the pelvic splanchnic nerves and pelvic plexuses bilaterally in each subject on oblique coronal thin-slab 10-mm-thick maximum intensity projection images and scored it with a 4-point grading scale (excellent, good, fair, poor). Both readers scored twice at 6-month intervals. Inter-observer and intra-observer variability were evaluated using Cohen's quadratically weighted κ statistics. Image artifact level was scored on a 4-point grading scale by other 2 abdominal radiologists in order to evaluate the correlation between the nerve visibility and the severity of imaging artifacts using the Spearman's correlation coefficient. Qualitative grading showed the following success rate (number of nerves qualitatively scored as excellent or good divided by total number of nerves): reader 1 (first set), 73% (19/26); reader 2 (first set), 77% (20/26); reader 1 (second set), 81% (21/26); and reader 2 (second set), 77% (20/26). Inter-observer agreement between readers 1 and 2 was excellent: $\kappa = 0.947$ (first set) and 0.845 (second set). Intra-observer agreement was also excellent: $\kappa = 0.810$ (reader 1) and 0.946 (reader 2). The visibility of pelvic splanchnic nerve and pelvic plexus showed a moderate correlation with the image artifact level ($\rho = 0.54$, $p = 0.004$). The authors concluded that the findings of this study demonstrated that RS-EPI DW-MRN is a promising approach for selectively visualizing the pelvic splanchnic nerve and pelvic plexus.

Kronlage and associates (2018) established normal values and identified demographic determinants of quantitative biomarkers in MRN.[21] A total of 60 healthy individuals (5 men and 5 women of every decade between 20 and 80 years) were examined according to a standardized MRN protocol at 3 T, including multi-echo T2 relaxometry. Nerve CSA, transverse relaxation time (T2), and PSD were assessed for the sciatic, tibial, median, ulnar, and radial nerves. Correlation with demographic variables, such as height, weight, body mass index (BMI), and age was expressed by Pearson coefficients and t-tests were used to compare MRN biomarkers between men and women with and without normalization to body weight and BMI by linear regression. The average nerve CSA correlated moderately with height ($r = 0.28$, $p = 0.04$), weight ($r = 0.40$, $p = 0.002$), and BMI ($r = 0.35$, $p = 0.008$), but not with age ($r = 0.23$, $p = 0.09$). While T2 did not correlate with demographic parameters, PSD was strongly inversely associated with BMI ($r = -0.64$, $p < 0.001$) and weight ($r = -0.557$, $p < 0.001$). Sex-dependent differences in imaging marker values were found for CSA but became negligible after normalization to body weight. The authors concluded that quantitative biomarkers of MRN co-varied with demographic variables. As particularly important determinants, these researchers identified body weight for nerve CSA and BMI for PSD. They stated that the presented normal values and demographic determinants may assist investigations into the potential of MRN biomarkers in further disease-specific studies.

In a prospective study, Schwarz and co-workers (2018) evaluated the imaging appearance and diagnostic value of plexus and peripheral nerve MRN in cervical radiculopathy.[22] A total of 24 patients were included with a diagnosis of cervical radiculopathy based on clinical examination, supporting electrophysiological examinations and spinal imaging consistent with the clinical syndrome. All patients then underwent a high-resolution MRN protocol including the brachial plexus from nerve roots to plexus cords using a 3D turbo spin echo with variable flip angle short tau inversion recovery and sagittal-oblique T2w spectral adiabatic inversion recovery sequence, and ulnar, median, and radial nerves at the upper arm and elbow in T2w fat saturated sequences. Two readers independently rated plexus elements regarding the presence of lesions at neuro-foraminal levels, roots, trunks, and cord segments. Median, ulnar, and radial nerves were likewise rated. Findings were then compared to a referenced standard of cervical radiculopathy that was defined as the combined diagnosis of clinical syndrome including supporting electrophysiological exams and matching positive spinal imaging, and diagnostic performance parameters were calculated. Additional quantitative and qualitative analysis assessed peripheral nerve caliber and normalized T2-signal at arm level in cervical radiculopathy and compared them to 25 inflammatory neuropathy controls. Cervical radiculopathy resulted in distinct plexus lesion patterns for each level of neuro-foraminal stenosis. Overall, brachial plexus MRN in cervical radiculopathy reached a sensitivity of 81%, a specificity of 96%, a PPV of 87%, and overall diagnostic accuracy of 87%. Initial spinal MRI showed multiple positive findings for clinically unaffected root levels and resulted in a specificity of 69%, a PPV of 54%, and an overall diagnostic accuracy of 78%; T2w peripheral nerve lesions were detected in 79% of cervical radiculopathy cases and imitated imaging appearance of inflammatory neuropathies both quantitatively and qualitatively. The authors concluded that complementing spine imaging in cervical radiculopathy with brachial plexus MRN can improve diagnostic accuracy by increasing specificity and PPV; T2w lesions of peripheral nerves can be caused by cervical radiculopathy, which must be considered a relevant diagnostic pitfall in MRN of peripheral neuropathies.

Jende and colleagues (2020) stated that diabetic polyneuropathy (DPN) is one of the most severe and yet most poorly understood complications of diabetes mellitus.[24] In-vivo imaging of dorsal root ganglia (DRG), a key structure for the understanding of DPN, has been restricted to animal studies. These have shown a correlation of decreased DRG volume with neuropathic symptom severity. In a pilot study, these investigators examined the correlations of DRG morphology and signal characteristics at 3 Tesla (3T) MRN with clinical and serological data in diabetic patients with and without DPN. In this cross-sectional study, subjects underwent 3T MRN of both L5 DRG using an isotropic 3D T2-weighted, fat-suppressed sequence with subsequent segmentation of DRG volume and analysis of normalized signal properties. Overall, 55 diabetes patients (66 ± 9 years; 32 men; 30 with DPN) participated in this study. DRG volume was smaller in patients with severe DPN when compared to patients with mild or moderate DPN (134.7 ± 21.86 versus 170.1 ± 49.22; p = 0.040). In DPN patients, DRG volume was negatively correlated with the neuropathy disability score (r = -0.43; 95 % CI: -0.66 to -0.14; p = 0.02), a measure of neuropathy severity. DRG volume showed negative correlations with triglycerides (r = -0.40; 95 % CI: -0.57 to -0.19; p = 0.006), and LDL cholesterol (r = -0.33; 95 % CI: -0.51 to -0.11; p = 0.04). There was a strong positive correlation of normalized MR signal intensity (SI) with the neuropathy symptom score in the subgroup of patients with painful DPN (r = 0.80; 95 % CI: 0.46 to 0.93; p = 0.005). DRG SI was positively correlated with HbA1c levels (r = 0.30; 95 % CI: 0.09 to 0.50; p = 0.03) and the triglyceride/HDL ratio (r = 0.40; 95 % CI: 0.19 to 0.57; p = 0.007). The authors concluded that in this 1st in-vivo study, they found DRG morphological degeneration and signal increase in correlation with neuropathy severity showing the potential importance of MR-based DRG evaluations in studying structural and functional changes in DPN. Moreover, these researchers stated that further longitudinal studies are needed to examine the impact of DRG volume and SI on the course of neuropathic symptoms in DPN and to further elucidate the underlying pathophysiological processes.

Sasaki and Kishimoto (2021) noted that recently, various neurological tests for evaluating small-fiber neuropathy have been developed; and MRN has also developed as a novel method to visualize diabetic neuropathy.[25] These investigators discussed the current status of DPN diagnosis focusing on the types of nerve fiber and MRN. They noted that the MRN lesion load in peripheral nerves and severity of the DPN correlated positively, and the most affected site was the sciatic nerve in the proximal thigh; the MRN lesion load reflected middle-to-large-fiber dysfunction, but not small C-fiber dysfunction; and differences in MRN lesions between type 1 and type 2 diabetes might reflect etiological differences in DPN. These researchers stated that several problems exist: the pathophysiological condition of MRN lesions was unknown; the optimal MRN imaging method and cut-off value for examining lesions have not been established; and overlap with healthy controls was large, and it was difficult to distinguish normal from abnormal. These researchers stated that MRN has the great advantage of being able to evaluate morphology, which is the most objective index, non-invasively, and might be extremely useful as a tool for evaluating DPN. Moreover, they stated that further studies including device innovation and longitudinal studies are needed.

Silva and colleagues (2022) stated that in view of the limitations of current methods for evaluating peripheral nerve injury, there is a need for technical innovations to improve diagnosis, surgical approach as well as post-operative monitoring.[26] These researchers carried out a systematic review to analyze the use of MR neurography in peripheral nerve injuries. This review focused on the use of MR neurography. The literature was searched in the PubMed, Cochrane Library and Virtual Health Library databases using the PICO method. A total of 162 articles were retrieved with the terms "magnetic resonance imaging" and "peripheral nerve

injury", with a filter for the last 10 years (2010 to 2020); 19 studies were eligible for the review. Most were reviews, with few systematic reviews of RCTs. Although not included in the recommended protocol, MRI is increasingly used due to its numerous advantages: it is non-invasive, providing objective visualization of neural and peri-neural tissues, fascicular representation as a result of high resolution, and objective visualization of serial interval images of successful treatment. This was one of the 1st systematic reviews of the literature regarding the use of MR neurography to examine peripheral nerve injury, highlighting the need to implement new imaging techniques in this field of medical practice.

Chen et al (2023) evaluated the diagnostic value of quantitative magnetic resonance neurography (MRN) in chronic inflammatory demyelinating polyradiculoneuropathy (CIDP).[27] Through literature searches in PubMed, Embase, Cochrane, Ovid MEDLINE and ClinicalTtrials.gov until March 1, 2023, the authors selected studies with the diagnostic performance of MRN in CIDP patients. The pooled estimated sensitivity and specificity of quantitative MRN parameters were determined by a bivariate random-effects model. Subgroup analysis was performed to evaluate the proper quantitative parameters and nerve sites. A total of 14 quantitative MRN studies with 23 results gave a pooled sensitivity of 0.73 (95% CI 0.66-0.79) and a pooled specificity of 0.89 (95% CI 0.84-0.92). The area under the curve (AUC) was 0.89 (95%CI 0.86-0.92). Subgroup analysis of quantitative parameters showed the fractional anisotropy (FA) with the highest sensitivity of 0.85 (95% CI 0.77-0.90) and cross-sectional area (CSA) with the highest specificity of 0.95 (95% CI 0.85-0.99). The pooled correlation coefficient for interobserver agreements was 0.90 (95%CI 0.82-0.95). The authors suggest that MRN may have some diagnostic value in CIDP patients.

SUMMARY OF EVIDENCE

Currently, the sensitivity, specificity, as well as positive predictive value (PPV) and negative predictive value (NPV) of MR neurography in the diagnosis and management of patients with peripheral nerve disorders remain unclear. Published studies do not directly compare MRN to other imaging procedures. The accuracy and clinical value of MR neurography have not been established due to a lack of well-designed controlled trials. It is unknown whether MRN would be used as an independent imaging tool or would more likely be used with other imaging techniques. At this time there is inadequate data regarding the diagnostic performance of MR neurography, in terms of defining the normal range of morphologies, the sensitivity and specificity of identification of abnormalities in comparison to other diagnostic tests, and the impact on the management of the individual.

Government Regulations National/Local:

There is no national or local coverage determination on this topic.

(The above Medicare information is current as of the review date for this policy. However, the coverage issues and policies maintained by the Centers for Medicare & Medicare Services [CMS, formerly HCFA] are updated and/or revised periodically. Therefore, the most current CMS information may not be contained in this document. For the most current information, the reader should contact an official Medicare source.)

Related Policies

- Magnetic Resonance Angiography/Magnetic Resonance Venography
- Magnetic Resonance Imaging, Low-Field
- Magnetic Resonance Imaging of the Breast
- Magnetic Resonance Spectroscopy
- Magnetoencephalography and Magnetic Source Imaging

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The articles reviewed in this research include those obtained in an Internet based literature search for relevant medical references through September 2024, the date the research was completed.

Joint BCBSM/BCN Medical Policy History

Policy Effective Date	BCBSM Signature Date	BCN Signature Date	Comments
5/1/13	2/19/13	3/4/13	Joint policy established
11/1/14	8/19/14	8/25/14	Update of non-covered service; additional references added. Policy status unchanged.
3/1/16	12/10/15	12/10/15	Routine policy maintenance. References updated. Policy status unchanged.
3/1/17	12/13/16	12/13/16	Routine policy maintenance. References updated. Removed Blue Cross Complete.
3/1/18	12/12/17	12/12/17	Routine policy maintenance. No change in policy status.
1/1/19	10/16/18	10/16/18	Routine policy maintenance. Added references 19-22. No change in policy status.
1/1/20	10/15/19		Routine policy maintenance. No change in policy status.
1/1/21	10/20/20		Routine policy maintenance. No change in policy status.
1/1/22	10/19/21		Rationale updated, added references 24 and 25. No change in policy status.
1/1/23	10/18/22		Routine policy maintenance, no change in policy status.
1/1/24	10/17/23		Routine policy maintenance, no change in status. Added reference 26. Vendor managed: N/A (ds)
1/1/25	10/15/24		Updated rationale, added reference #27. No change in policy status. Vendor managed: N/A (ds)

Next Review Date: 4th Qtr. 2025

BLUE CARE NETWORK BENEFIT COVERAGE
POLICY: MAGNETIC RESONANCE NEUROGRAPHY

I. Coverage Determination:

Commercial HMO (includes Self-Funded groups unless otherwise specified)	Not covered.
BCNA (Medicare Advantage)	See government section.
BCN65 (Medicare Complementary)	Coinsurance covered if primary Medicare covers the service.

II. Administrative Guidelines:

N/A