Preauthorization is required.

The following protocol contains medical necessity criteria that apply for this service. The criteria are also applicable to services provided in the local Medicare Advantage operating area for those members, unless separate Medicare Advantage criteria are indicated. If the criteria are not met, reimbursement will be denied and the patient cannot be billed. Please note that payment for covered services is subject to eligibility and the limitations noted in the patient’s contract at the time the services are rendered.

<table>
<thead>
<tr>
<th>Populations</th>
<th>Interventions</th>
<th>Comparators</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individuals:</td>
<td>Interventions of interest are:</td>
<td>Comparators of interest are:</td>
<td>Relevant outcomes include:</td>
</tr>
<tr>
<td>• With suspected inherited motor and sensory peripheral neuropathy</td>
<td>• Testing for genes associated with inherited peripheral neuropathies</td>
<td>• Clinical management without genetic testing</td>
<td>• Test validity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Symptoms</td>
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<td></td>
<td></td>
<td></td>
<td>• Change in disease status</td>
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</tbody>
</table>

**DESCRIPTION**

The inherited peripheral neuropathies are a heterogeneous group of diseases that may be inherited in an autosomal dominant, autosomal recessive, or X-linked dominant manner. These diseases can generally be diagnosed based on clinical presentation, nerve conduction studies, and family history. Genetic testing has been used to diagnose specific inherited peripheral neuropathies.

**SUMMARY OF EVIDENCE**

For individuals with suspected inherited motor and sensory peripheral neuropathy who receive testing for genes associated with inherited peripheral neuropathies, the evidence includes case-control and genome-wide association studies. The relevant outcomes are test validity, symptoms, and change in disease status. For the evaluation of hereditary motor and sensory peripheral neuropathies and hereditary neuropathy with liability to pressure palsies, the diagnostic testing yield is likely to be high, particularly when sequential testing is used based on patient phenotype. However, the clinical utility of genetic testing to confirm a diagnosis in a patient with a clinical diagnosis of an inherited peripheral neuropathy is unknown. No direct evidence for improved outcomes with the use of genetic testing for hereditary motor and sensory peripheral neuropathies and hereditary neuropathy with liability to pressure palsies was identified. However, a chain of evidence supports the use of genetic testing to establish a diagnosis in cases of suspected inherited motor or sensory neuropathy, when a diagnosis cannot be made by other methods, to initiate supportive therapies. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

**POLICY**

Genetic testing is considered medically necessary when the diagnosis of an inherited peripheral motor or sen-
Genetic testing for the Diagnosis of Inherited Peripheral Neuropathies

POLICY GUIDELINES
This protocol addresses the hereditary motor and sensory peripheral neuropathies, of which peripheral neuropathy is the primary clinical manifestation. A number of other hereditary disorders may have neuropathy as an associated finding, but typically have other central nervous system and occasional other systemic findings. Examples include Refsum disease, various lysosomal storage diseases, and mitochondrial disorders.

GENETIC COUNSELING
Genetic counseling is primarily aimed at patients who are at risk for inherited disorders, and experts recommend formal genetic counseling in most cases when genetic testing for an inherited condition is considered. The interpretation of the results of genetic tests and the understanding of risk factors can be very difficult and complex. Therefore, genetic counseling will assist individuals in understanding the possible benefits and harms of genetic testing, including the possible impact of the information on the individual’s family. Genetic counseling may alter the utilization of genetic testing substantially and may reduce inappropriate testing. Genetic counseling should be performed by an individual with experience and expertise in genetic medicine and genetic testing methods.

MEDICARE ADVANTAGE
For Medicare Advantage, genetic testing for the diagnosis of an inherited peripheral neuropathies is considered not medically necessary if the above criteria are not met.

BACKGROUND
INHERITED PERIPHERAL NEUROPATHIES
Inherited peripheral neuropathies are a clinically and genetically heterogeneous group of disorders. The estimated prevalence in aggregate is one in 2,500 persons, making inherited peripheral neuropathies the most common inherited neuromuscular disease.\(^1\)

Peripheral neuropathies can be subdivided into two major categories: primary axonopathies and primary myelinopathies, depending on which portion of the nerve fiber is affected. The further anatomic classification includes fiber type (e.g., motor vs. sensory, large vs. small) and gross distribution of the nerves affected (e.g., symmetry, length-dependency).

Inherited peripheral neuropathies are divided into the hereditary motor and sensory neuropathies, hereditary neuropathy with liability to pressure palsies (HNPP), and other miscellaneous, rare types (e.g., hereditary brachial plexopathy, hereditary sensory, autonomic neuropathies). Other hereditary metabolic disorders, such as Friedreich ataxia, Refsum disease, and Krabbe disease, may be associated with motor and/or sensory neuropathies but typically have other predominating symptoms. This evidence review focuses on the hereditary motor and sensory neuropathies and HNPP.

A genetic etiology of peripheral neuropathy is typically suggested by generalized polyneuropathy, family history, lack of positive sensory symptoms, early age of onset, symmetry, associated skeletal abnormalities, and very
slowly progressive clinical course. A family history of at least three generations with details on health issues, the cause of death, and age at death should be collected.

Charcot-Marie-Tooth Disease

_Hereditary Motor and Sensory Neuropathies_

Most inherited polyneuropathies were originally described clinically as variants of CMT disease. The clinical phenotype of CMT is highly variable, ranging from minimal neurologic findings to the classic picture with pes cavus and “stork legs” to a severe polyneuropathy with respiratory failure. CMT disease is genetically and clinically heterogeneous. Variants in more than 30 genes and more than 44 different genetic loci have been associated with the inherited neuropathies. Also, different pathogenic variants in a single gene can lead to different inherited neuropathy phenotypes and inheritance patterns. A 2016 cross-sectional study of 520 children and adolescents with CMT found variability in CMT-related symptoms across the five most commonly represented subtypes.

CMT subtypes are characterized by variants in one of several myelin genes, which lead to abnormalities in myelin structure, function, or upkeep. There are seven subtypes of CMT, with type 1 and 2 representing the most common hereditary peripheral neuropathies.

Most cases of CMT are autosomal dominant, although autosomal recessive and X-linked dominant forms exist. Most cases are CMT type 1 (approximately 40%-50% of all CMT cases, with 78%-80% of those due to PMP22 variants). CMT type 2 is associated with 10% to 15% of CMT cases, with 20% of those due to MFN2 variants.

A summary of the molecular genetics of CMT is outlined in Table 1.

Table 1. Molecular Genetics of CMT Variants

<table>
<thead>
<tr>
<th>Locus</th>
<th>Gene</th>
<th>Protein Product</th>
<th>Prevalence (if known)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CMT type 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMT1A</td>
<td>PMP22</td>
<td>Peripheral myelin protein 22</td>
<td>70%-80% of CMT1</td>
</tr>
<tr>
<td>CMT1B</td>
<td>MPZ</td>
<td>Myelin P0 protein</td>
<td>10%-12% of CMT1</td>
</tr>
<tr>
<td>CMT1C</td>
<td>LITAF</td>
<td>Lipopolysaccharide-induced tumor necrosis factor-α factor</td>
<td>≈1% of CMT1</td>
</tr>
<tr>
<td>CMT1D</td>
<td>EGR2</td>
<td>Early growth response protein 2</td>
<td></td>
</tr>
<tr>
<td>CMT1E</td>
<td>PMP22</td>
<td>Peripheral myelin protein 22 (sequence changes)</td>
<td>≈1% of CMT1</td>
</tr>
<tr>
<td>CMT1F/2E</td>
<td>NEFL</td>
<td>Neurofilament light polypeptide</td>
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</tr>
<tr>
<td><strong>CMT type 2</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CMT2A1</td>
<td>KIF1B</td>
<td>Kinesin-like protein KIF1B</td>
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<tr>
<td>CMT2A2</td>
<td>MFN2</td>
<td>Mitofusin-2</td>
<td>20% of CMT2</td>
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<tr>
<td>CMT2B</td>
<td>RAB7A</td>
<td>Ras-related protein Rab-7</td>
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<tr>
<td>CMT2B1</td>
<td>LMNA</td>
<td>Lamin A/C</td>
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<tr>
<td>CMT2B2</td>
<td>MED25</td>
<td>Mediator of RNA polymerase II transcription subunit 25</td>
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<tr>
<td>CMT2C</td>
<td>TRPV4</td>
<td>Transient receptor potential cation channel subfamily V member 4</td>
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<td>CMT2D</td>
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<td>Glycyl-tRNA synthetase</td>
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<td>CMT2S</td>
<td>IGHMBP2</td>
<td>DNA-binding protein SMUBP-2</td>
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<tr>
<td>CMT2T</td>
<td>DNAJB2</td>
<td>DnaJ homolog subfamily B member 2</td>
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</table>
The clinical features of CMT are briefly summarized.

CMT TYPE 1

CMT type 1 (CMT1) is an autosomal dominant, demyelinating peripheral neuropathy characterized by distal muscle weakness and atrophy, sensory loss, and slow nerve conduction velocity. It is usually slowly progressive and often associated with pes cavus foot deformity, bilateral foot drop, and palpably enlarged nerves, especially the ulnar nerve at the olecranon groove and the greater auricular nerve. Affected people usually become symptomatic between ages five and 25 years, and lifespan is not shortened. Less than 5% of people become wheelchair-dependent. CMT1 is inherited in an autosomal dominant manner. The CMT1 subtypes (CMT 1A-E) are separated by molecular findings and are often clinically indistinguishable. CMT1A accounts for 70% to 80% of all CMT1, and about two-thirds of probands with CMT1A have inherited the disease-causing variant, and about one-third have CMT1A as the result of a de novo variant.

CMT1A involves duplication of the PMP22 gene. PMP22 encodes an integral membrane protein, peripheral membrane protein 22, which is a major component of myelin in the peripheral nervous system. The phenotypes associated with this disease arise because of abnormal PMP22 gene dosage effects. Two normal alleles represent the normal wild-type condition. Four normal alleles (as in the homozygous CMT1A duplication) result in the most severe phenotype, whereas three normal alleles (as in the heterozygous CMT1A duplication) cause a less severe phenotype.

CMT TYPE 2

CMT type 2 (CMT2) is a non-demyelinating (axonal) peripheral neuropathy characterized by distal muscle weakness and atrophy, mild sensory loss, and normal or near-normal nerve conduction velocities. Clinically, CMT2 is similar to CMT1, although typically less severe. The subtypes of CMT2 are similar clinically and distinguished only by molecular genetic findings. CMT2B1, CMT2B2, and CMT2H/K are inherited in an autosomal recessive manner; all other subtypes of CMT2 are inherited in an autosomal dominant manner. The most common subtype of CMT2 is CMT2A, which accounts for approximately 20% of CMT2 cases and is associated with variants in the MFN2 gene.
X-LINKED CMT

CMT X type 1 (CMTX1) is characterized by a moderate-to-severe motor and sensory neuropathy in affected males and mild to no symptoms in carrier females. Sensorineural deafness and central nervous system symptoms also occur in some families. CMT X type 1 is inherited in an X-linked dominant manner. Molecular genetic testing of GJB1 (Cx32), which is available on a clinical basis, detects about 90% of cases of CMT X type 1.

CMT TYPE 4

CMT type 4 is a form of hereditary motor and sensory neuropathy that is inherited in an autosomal recessive fashion and occurs secondary to myelinopathy or axonopathy. It occurs more rarely than the other forms of CMT neuropathy, but some forms may be rapidly progressive and/or associated with severe weakness.

Hereditary Neuropathy with Liability to Pressure Palsies

The largest proportion of CMT1 cases are due to variants in PMP22. In HNPP (also called tomaculous neuropathy), inadequate production of PMP22 causes nerves to be more susceptible to trauma or minor compression or entrapment. HNPP patients rarely present symptoms before the second or third decade of life. However, some have reported presentation as early as birth or as late as the seventh decade of life. The prevalence is estimated at 16 persons per 100,000, although some authors have indicated a potential for underdiagnosis of the disease. An estimated 50% of carriers are asymptomatic and do not display abnormal neurologic findings on clinical examination. HNPP is characterized by repeated focal pressure neuropathies such as carpal tunnel syndrome and peroneal palsy with foot drop and episodes of numbness, muscular weakness, atrophy, and palsies due to minor compression or trauma to the peripheral nerves. The disease is benign with complete recovery occurring within a period of days to months in most cases, although an estimated 15% of patients have residual weakness following an episode. Poor recovery usually involves a history of prolonged pressure on a nerve, but, in these cases, the remaining symptoms are typically mild.

PMP22 is the only gene for which a variant is known to cause HNPP. A large deletion occurs in approximately 80% of patients, and the remaining 20% of patients have single nucleotide variants (SNVs) and small deletions in the PMP22 gene. One normal allele (due to a 17p11.2 deletion) results in HNPP and a mild phenotype. SNVs in PMP22 have been associated with a variable spectrum of HNPP phenotypes ranging from mild symptoms to representing a more severe, CMT1-like syndrome. Studies have also reported that the SNV frequency may vary considerably by ethnicity. About 10% to 15% of variant carriers remain clinically asymptomatic, suggesting incomplete penetrance.

Treatment

Currently, there is no therapy to slow the progression of neuropathy for the inherited peripheral neuropathies. A 2015 systematic review of exercise therapies for CMT including nine studies described in 11 articles reported significant improvements with functional activities and physiological adaptations with exercise. Supportive treatment, if necessary, is generally provided by a multidisciplinary team including neurologists, physiatrists, orthopedic surgeons, and physical and occupational therapists. Treatment choices are limited to physical therapy, use of orthotics, surgical treatment for skeletal or soft tissue abnormalities, and drug treatment for pain. Avoidance of obesity and drugs associated with nerve damage (e.g., vincristine, paclitaxel, cisplatin, isoniazid, nitrofurantoin) is recommended in CMT patients.

Supportive treatment for HNPP can include transient bracing (e.g., wrist splint or ankle-foot orthosis), which may become permanent in some cases of foot drop. Prevention of HNPP manifestations can be accomplished by wearing protective padding (e.g., elbow or knee pads) to prevent trauma to nerves during activity. Some have reported that vincristine should also be avoided in HNPP patients. Ascorbic acid has been investigated as a treatment for CMT1A based on animal models, but a 2013 trial in humans did not demonstrate significant clinical benefit. Attarian et al (2014) reported results of an exploratory phase two randomized, double-blind, pla-
cebo-controlled trial of PXT3003, a low-dose combination of three approved compounds (baclofen, naltrexone, sorbitol) in 80 adults with CMT1A.20 The trial demonstrated the safety and tolerability of the drug. Mandel et al (2015) included this RCT and three other trials (one of ascorbic acid, two of PXT3003) in a meta-analysis.21

**MOLECULAR GENETIC TESTING**

Multiple laboratories offer individual variant testing for genes involved in hereditary sensory and motor neuropathies, which would typically involve sequencing analysis via Sanger sequencing or next-generation sequencing followed by deletion/duplication analysis (i.e., with array comparative genomic hybridization) to detect large deletions or duplications. For the detection of variants in MFN2, whole gene or select exome sequence analysis is typically used to identify SNVs, in addition to or followed by deletion or duplication analysis for the detection of large deletions or duplications.

A number of genetic panel tests for the assessment of peripheral neuropathies are commercially available. For example, GeneDx (Gaithersburg, MD) offers an Axonal CMT panel, which uses next-generation sequencing and exon array comparative genomic hybridization. The genes tested include AARS, BSCL2, DNM2, DYNC1H1, GARS, GDAP1, GJB1, Hspb1, HSPB8, LMNA, LRSAM1, MED25, MFN2, MPZ, NEFL, PRPS1, RAB7A, and TRPV4.22

InterGenetics (Athens, Greece) offers a next-generation sequencing panel for neuropathy that includes 42 genes involved in CMT, along with other hereditary neuropathies. Fulgent Clinical Diagnostics Lab offers a broader NGS panel for CMT that includes 48 genes associated with CMT and other neuropathies and myopathies.

**REGULATORY STATUS**

Clinical laboratories may develop and validate tests in-house and market them as a laboratory service; laboratory-developed tests must meet the general regulatory standards of the Clinical Laboratory Improvement Amendments. Genetic testing for the diagnosis of inherited peripheral neuropathies is available under the auspices of the Clinical Laboratory Improvement Amendments. Laboratories that offer laboratory-developed tests must be licensed by the Clinical Laboratory Improvement Amendments for high-complexity testing. To date, the FDA has chosen not to require any regulatory review of this test.

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Services that are the subject of a clinical trial do not meet our Technology Assessment and Medically Necessary Services Protocol criteria and are considered investigational. For explanation of experimental and investigational, please refer to the Technology Assessment and Medically Necessary Services Protocol.

It is expected that only appropriate and medically necessary services will be rendered. We reserve the right to conduct prepayment and postpayment reviews to assess the medical appropriateness of the above-referenced procedures. Some of this protocol may not pertain to the patients you provide care to, as it may relate to products that are not available in your geographic area.

**REFERENCES**

We are not responsible for the continuing viability of web site addresses that may be listed in any references below.

23. Aretz S, Rautenstrauss B, Timmerman V. Clinical utility gene card for: HMSN/HNPP HMSN types 1, 2, 3, 6 (CMT1,2,4, DSN, CHN, GAN, CCFDN, HNA); HNPP. Eur J Hum Genet. Sep 2010;18(9). PMID 20512157
34. National Government Services, Inc. (Primary Geographic Jurisdiction 06 & K - Illinois, Minnesota, Wisconsin, Connecticut, New York - Entire State, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont) Local Coverage Determination (LCD): Molecular Pathology Procedures (L35000), Revision Effective Date for services performed on or after 07/01/2020.