Policy Statement

Genetic testing for Rett syndrome-associated genes (e.g., MECP2, FOXG1, or CDKL5) may be considered medically necessary to establish a genetic diagnosis of Rett syndrome in a child with developmental delay and signs/symptoms of Rett syndrome, when a definitive diagnosis cannot be made without genetic testing.

Targeted genetic testing for a known familial Rett syndrome-associated variant may be considered medically necessary to determine carrier status of a mother or a sister of an individual with Rett syndrome.

All other indications for genetic testing for Rett syndrome-associated genes (e.g., MECP2, FOXG1, or CDKL5) are considered investigational, including either of the following:
- Carrier testing (preconception or prenatal)
- Testing of asymptomatic family members to determine future risk of disease

Genetics Nomenclature Update

Human Genome Variation Society (HGVS) nomenclature is used to report information on variants found in DNA and serves as an international standard in DNA diagnostics. It is being implemented for genetic testing medical evidence review updates starting in 2017 (see Table PG1). HGVS nomenclature is recommended by HGVS, the Human Variome Project, and the Human Genome Organization (HUGO).

The American College of Medical Genetics and Genomics (ACMG) and Association for Molecular Pathology (AMP) standards and guidelines for interpretation of sequence variants represent expert opinion from ACMG, AMP, and the College of American Pathologists. These recommendations primarily apply to genetic tests used in clinical laboratories, including genotyping, single genes, panels, exomes, and genomes. Table PG2 shows the recommended standard terminology—"pathogenic," "likely pathogenic," "uncertain significance," "likely benign," and "benign"—to describe variants identified that cause Mendelian disorders.

Table PG1. Nomenclature to Report on Variants Found in DNA

<table>
<thead>
<tr>
<th>Previous</th>
<th>Updated</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutation</td>
<td>Disease-associated variant</td>
<td>Disease-associated change in the DNA sequence</td>
</tr>
<tr>
<td>Variant</td>
<td>Change in the DNA sequence</td>
<td></td>
</tr>
<tr>
<td>Familial variant</td>
<td>Disease-associated variant identified in a proband for use in subsequent targeted genetic testing in first-degree relatives</td>
<td></td>
</tr>
</tbody>
</table>
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.

Coding
The following CPT coding describes genetic testing for Rett syndrome:
- **81302**: MECP2 (methyl CpG binding protein 2) (e.g., Rett syndrome) gene analysis; full sequence analysis
- **81303**: MECP2 (methyl CpG binding protein 2) (e.g., Rett syndrome) gene analysis; known familial variant
- **81304**: MECP2 (methyl CpG binding protein 2) (e.g., Rett syndrome) gene analysis; duplication/deletion variants

CPT code **81404** includes the following testing for FOXG1:
- FOXG1 (forkhead box G1) (e.g., Rett syndrome), full gene sequence

CPT code **81406** includes the following testing for CDKL5:
- CDKL5 (cyclin-dependent kinase-like 5) (e.g., early infantile epileptic encephalopathy), full gene sequence

Description
Rett syndrome (RTT), a neurodevelopmental disorder, is usually caused by pathogenic variants in the methyl-CpG-binding protein 2 (MECP2) gene. Genetic testing is available to determine whether a pathogenic variant exists in RTT-associated genes (e.g., MECP2, FOXG1, or CDLK5) in a patient with clinical features of RTT or in a patient’s family member.

Related Policies
- N/A

Benefit Application
Benefit determinations should be based in all cases on the applicable contract language. To the extent there are any conflicts between these guidelines and the contract language, the contract language will control. Please refer to the member’s contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

Some state or federal mandates [e.g., Federal Employee Program (FEP)] prohibits plans from denying Food and Drug Administration (FDA)-approved technologies as investigational. In these instances, plans may have to consider the coverage eligibility of FDA-approved technologies on the basis of medical necessity alone.

Regulatory Status
Clinical laboratories may develop and validate tests in-house and market them as a laboratory service; laboratory-developed tests (LDTs) must meet the general regulatory standards of the
Clinical Laboratory Improvement Amendments (CLIA). Genetic testing for Rett syndrome is available under the auspices of CLIA. Laboratories that offer LDTs must be licensed by CLIA for high-complexity testing. To date, the U.S. Food and Drug Administration has chosen not to require any regulatory review of this test.

**Rationale**

**Background**

**Rett Syndrome**

Rett syndrome (RTT) is a severe neurodevelopmental disorder primarily affecting girls, with an incidence of 1:10,000 female births, making it among the most common genetic causes of intellectual disability in girls. RTT is characterized by apparent normal development for the first 6 to 18 months of life, followed by regression of intellectual functioning, acquired fine and gross motor skills, and social skills. Purposeful use of the hands is replaced by repetitive stereotyped hand movements, such as hand-wringing. Other clinical manifestations include seizures, disturbed breathing patterns with hyperventilation and periodic apnea, scoliosis, growth retardation, and gait apraxia.

There is wide variability in the rate of progression and severity of the disease. In addition to the classic form of RTT, there are recognized atypical variants. Variants of RTT may appear with a severe or a milder form. The severe variant has no normal developmental period; individuals with a milder phenotype experience less dramatic regression and milder expression of the characteristics of classical RTT. Diagnostic criteria for typical (or classic) RTT and atypical (or variant) RTT have been established. For typical RTT, a period of regression followed by recovery or stabilization and fulfillment of all the main criteria are required to meet the diagnostic criteria for classic RTT. For atypical RTT, a period of regression followed by recovery or stabilization, at least 2 of the 4 main criteria, plus 5 of 11 supportive are required to meet the diagnostic criteria of variant RTT.

**Treatment**

Currently, there are no specific treatments that halt or reverse disease progression, and there are no known medical interventions that will change the outcome of patients with RTT. Management is mainly symptomatic and individualized, focusing on optimizing each patient’s abilities. A multidisciplinary approach is usually applied, with specialist input from dietitians, physical therapists, occupational therapists, speech therapists, and music therapists. Regular monitoring for scoliosis (seen in ≈87% of patients by age 25 years) and possible heart abnormalities, particularly cardiac conduction abnormalities, may be recommended. Spasticity can have a major impact on mobility; physical therapy and hydrotherapy may prolong mobility. Occupational therapy can help children develop communication strategies and skills needed for performing self-directed activities (e.g., dressing, feeding, practicing arts and crafts).

Pharmacologic approaches to managing problems associated with RTT include melatonin for sleep disturbances and several agents to control breathing disturbances, seizures, and stereotypic movements. RTT patients have an increased risk of life-threatening arrhythmias associated with a prolonged QT interval, and avoidance of a number of drugs is recommended, including prokinetic agents, antipsychotics, tricyclic antidepressants, antiarrhythmics, anesthetic agents, and certain antibiotics.

In a mouse model of RTT, genetic manipulation of the MECP2 gene has demonstrated reversibility of the genetic defect.

**Genetics**

RTT is an X-linked dominant genetic disorder. Pathogenic variants in MECP2, which is thought to control expression of several genes, including some involved in brain development, were first reported in 1999. Subsequent screening has shown that over 80% of patients with classic RTT have pathogenic variants in the MECP2 gene. More than 200 pathogenic variants in MECP2
have been associated with RTT. However, 8 of the most commonly occurring missense and nonsense variants account for almost 70% of all cases; small C-terminal deletions account for approximately 10% and large deletions, 8% to 10%. MECP2 variant type is associated with disease severity. Whole duplications of the MECP2 gene have been associated with severe X-linked intellectual disability with progressive spasticity, no or poor speech acquisition, and acquired microcephaly. Additionally, the pattern of X-chromosome inactivation influences the severity of the clinical disease in females.

Because the spectrum of clinical phenotypes is broad, to facilitate genotype-phenotype correlation analyses, the International Rett Syndrome Association has established a locus-specific MECP2 variation database (RettBASE) and a phenotype database (InterRett).

Approximately 99.5% of cases of RTT are sporadic, resulting from a de novo variant, which arise almost exclusively on the paternally derived X chromosome. The remaining 0.5% of cases are familial and usually explained by germline mosaicism or favorably skewed X-chromosome inactivation in the carrier mother that results in her being unaffected or only slightly affected (mild intellectual disability). In the case of a carrier mother, the recurrence risk of RTT is 50% if a variant is not identified in leukocytes of the mother, the risk to a sibling of the proband is below 0.5% (because germline mosaicism in either parent cannot be excluded).

Identification of a variant in MECP2 does not necessarily equate to a diagnosis of RTT. Rare cases of MECP2 variants also have been reported in other clinical phenotypes, including individuals with an Angelman-like picture, nonsyndromic X-linked intellectual disability, PPM-X syndrome (an X-linked genetic disorder characterized by psychotic disorders [most commonly bipolar disorder], parkinsonism, and intellectual disability), autism, and neonatal encephalopathy. Recent studies have revealed that different classes of genetic variants in MECP2 result in variable clinical phenotypes and overlap with other neurodevelopmental disorders.

A proportion of patients with a clinical diagnosis of RTT do not appear to have pathogenic variants in the MECP2 gene. Two other genes (CDKL5, FOXG1) have been shown to be associated with atypical variants.

**Literature Review**

This evidence review addresses the following categories of genetic testing: 1a (diagnostic testing of an affected individual's germline to benefit the individual), 3 (testing an asymptomatic individual to determine future risk of disease), and 5a/5b (preconception and prenatal carrier testing) (see Appendix Table 1 for genetic testing categories).

Validation of the clinical use of any genetic test focuses on 3 main principles: (1) analytic validity, which refers to the technical accuracy of the test in detecting a variant that is present or in excluding a variant that is absent; (2) clinical validity, which refers to the diagnostic performance of the test (sensitivity, specificity, positive and negative predictive values) in detecting clinical disease; and (3) clinical utility (i.e., how the results of the diagnostic test will be used to change management of the patient and whether these changes in management lead to clinically important improvements in health outcomes). Following is a summary of the key literature.

**Testing Individuals with Signs or Symptoms of Rett Syndrome**

**Clinical Context and Test Purpose**

The purpose of genetic testing of individuals with signs or symptoms of Rett syndrome (RTT) is to determine the underlying pathogenic variant, predict potential disease severity, to initiate surveillance for potential disease complications (e.g., musculoskeletal deformities, autonomic dysfunction), and to direct treatments.
The relevant question addressed in this evidence review is: Does genetic testing for RTT-associated genes in individuals with suspected but not confirmed RTT lead to improved health outcomes?

The following PICOTS were used to select literature to inform this review.

**Patients**
The relevant population of interest includes individuals with signs or symptoms of RTT.

**Interventions**
The relevant intervention of interest is genetic testing for RTT-associated genes.

**Comparators**
The relevant comparator of interest is standard clinical management without genetic testing.

**Outcomes**
The potential beneficial outcomes of primary interest are establishing a genetic diagnosis for RTT and predicting potential disease severity and course to initiate surveillance and treatments for disease complications. Some genetic variants may be associated with prolonged QT syndrome, which would require periodic screening and avoidance of certain medications.

Potential harmful outcomes are those resulting from a false-positive or false-negative test results. False-positive test results can lead to unnecessary surveillance (e.g., musculoskeletal or autonomic dysfunction) and treatments (e.g., spinal fusion for scoliosis or kyphosis). False-negative test results can lead to lack of appropriate surveillance and treatments.

**Timing**
The time frame for outcome measures varies from short-term development of a severe neurodevelopmental disorder to long-term complications such as autonomic dysfunction, scoliosis or kyphosis, and growth retardation.

**Setting**
The primary settings would be in pediatric neurology, developmental pediatrics, or genetics outpatient offices.

**Analytic Validity**
Analytic validity is the technical accuracy of the test in detecting a variant that is present or in excluding a variant that is absent.

The test is generally done as full gene sequencing of the MECP2 (methyl-CpG-binding protein 2) gene to diagnose atypical or classic RTT and as multiplex ligation probe amplification (MLPA) for duplication and deletion analysis. Familial variant testing may be done with targeted sequencing. FOXL1 or CDKL5 sequencing may be done for atypical RTT.

According to a large reference laboratory, MECP2 testing for RTT has an analytic sensitivity for sequencing of 99% and for MLPA, 90%; analytic specificity is 99% for sequencing and for MLPA, 98%.15

**Clinical Validity**
Clinical validity is the diagnostic performance of the test (sensitivity, specificity, and positive and negative predictive values) in detecting clinical disease.

Huppke et al (2000) analyzed the MECP2 gene in 31 female patients diagnosed clinically with RTT.16 Sequencing revealed variants in 24 (77%) of the 31 patients. Of the 7 patients in whom no variants were found, 5 fulfilled criteria for classic RTT. In this study, 17 different variants were detected, 11 of which had not been previously described. Several females carrying the same...
variant displayed different phenotypes, suggesting that factors other than the type or position of variants influenced the severity of RTT.

Cheadle et al (2000) analyzed variants in 48 females with classic sporadic RTT, 7 families with possible familial RTT, and 5 sporadic females with features suggestive, but not diagnostic, of RTT.\textsuperscript{17} The entire MECP2 gene was sequenced in all cases. Variants were identified in 44 (80\%) of 55 unrelated classic sporadic and familial RTT patients. Only 1 (20\%) of 5 sporadic cases with suggestive but nondiagnostic features of RTT had variants identified. Twenty-one different variants were identified (12 missense, 4 nonsense, and 5 frame-shift variants); 14 of the variants identified were novel. Significantly milder disease was noted in patients carrying missense variants compared with those with truncating variants.

The 2 studies previously discussed were included in a summary of 6 articles by Lotan et al (2006) who attempted to elicit a genotype-phenotype correlation.\textsuperscript{2} The authors found that these studies had yielded inconsistent results and that further controlled studies were needed before valid conclusions could be drawn about the effect of variant type on phenotypic expression. Two subsequent studies used the InterRett database to examine genotype and RTT severity.\textsuperscript{18,19} Of 357 girls with epilepsy who had MECP2 genotype recorded, those with large deletions were more likely than those with 10 other common variants to have active epilepsy (odds ratio [OR], 3.71; 95\% confidence interval [CI], 1.13 to 12.17; \( p = 0.03 \)) and had the earliest median age at epilepsy onset (3 years 5 months). Among all girls in the database, those with large deletions were more likely to have never walked (OR=0.42; 95\% CI, 0.22 to 0.79; \( p = 0.007 \)). Of 260 girls with classic RTT enrolled in the multicenter RTT Natural History study (NCT00299312), those with the R133C substitution variant had clinically less severe disease, assessed by the Clinical Severity, Motor Behavior Analysis, and Physician Summary scales.\textsuperscript{7} Fabio et al (2014) reported similar genotype-phenotype correlations among 144 patients with RTT in Italy.\textsuperscript{20}

Halbach et al (2016) analyzed a cohort from a group of 132 female patients between 2 and 43 years of age with well-defined RTT with extended clinical, molecular, and neurophysiological assessments.\textsuperscript{21} Genotype-phenotype analyses of clinical features and cardiorespiratory data were performed after grouping variants by the same type and localization or having the same putative biologic effect on the MeCP2 protein, and subsequently on 8 single recurrent pathogenic variants. A less severe phenotype was seen in females with C-terminal segment of MECP2 (p.R133C and p.R294X variants). Autonomic disturbances were present in all females and not restricted to nor influenced by 1 specific group or any single recurrent pathogenic variant. The objective information from noninvasive neurophysiological evaluation of the disturbed central autonomic control is of great importance organizing the lifelong care for females with RTT. The study concluded that further research is needed to provide insights into the pathogenesis of autonomic dysfunction, and to develop evidence-based management in RTT.

Pidock et al (2016) identified 96 RTT patients with pathogenic variants in the MECP2 gene.\textsuperscript{22} Among 11 pathogenic variant groups, a statistically significant group effect of variant type was observed for self-care, upper-extremity function, and mobility on standardized measures administered by occupational and physical therapists. Patients with R133C and uncommon variants tended to perform best on upper-extremity and self-care items, whereas patients with R133C, R306C, and R294X variants had the highest scores on the mobility items. The worst performers on upper-extremity and self-care items were patients with large deletions (R255X, R168X, and T158M variants). The lowest scores for mobility were found in patients with T158M, R255X, R168X, and R270X variants. On categorical variables as reported by parents at the time of initial evaluation, patients with R133C and R294X variants were most likely to have hand use; those with R133C, R294X, R306C, and small deletions were most likely to be ambulatory; and those with the R133C variant were most likely to be verbal.

Sajan et al (2017) analyzed 22 RTT patients without apparent MECP2, CDKL5, and FOXG1 pathogenic variants were subjected to both whole-exome sequencing and single-nucleotide variant array-based copy-number variant analyses.\textsuperscript{23} Three patients had MECP2 variants initially
missed by clinical testing. Of the remaining 19, 17 (89.5%) had 29 other likely pathogenic intragenic variants and/or copy number variants (10 patients had ≥2). Thirteen patients had variants in a gene/region previously reported in other neurodevelopmental disorders, thereby providing a potential diagnostic yield of 68.4%. The genetic etiology of RTT without MECP2, CDKL5, and FOXG1 variants is heterogeneous, overlaps with other neurodevelopmental disorders, and is complicated by a high variant burden. Dysregulation of chromatin structure and abnormal excitatory synaptic signaling may form 2 common pathologic bases of RTT.

**Section Summary: Clinical Validity**
Evidence from several small studies has indicated that the clinical sensitivity of genetic testing for classic RTT is reasonably high, in the range of 75% to 80%. However, sensitivity may be lower when classic RTT features are absent. Clinical specificity is unknown, but also is likely to be high, because only rare cases of MECP2 variants have been reported in other clinical phenotypes, including individuals with an Angelman-like picture, nonsyndromic X-linked intellectual disability, PPM-X syndrome, autism, and neonatal encephalopathy. Recent studies have indicated that specific classes, types, or burden of pathogenic variants in genes associated with RTT affect severity of disease (e.g., degree of autonomic dysfunction, functional outcomes, degree of neurodevelopmental disorder).

**Clinical Utility**
**Direct Evidence**
Direct evidence of clinical utility is provided by studies that have compared health outcomes for patients managed with and without the test. No studies were identified that demonstrated direct evidence of clinical utility.

**Indirect Evidence**
Indirect evidence of clinical utility rests on clinical validity. There is no specific treatment for RTT; however, identification of the pathogenic variant leading to RTT has been found to correlate with disease severity and predict potential complications of disease (e.g., autonomic dysfunction and functional outcomes such as mobility). Increased surveillance for clinical manifestations, such as scoliosis or cardiac arrhythmia, and tailoring of ancillary treatments, such as occupational or physical therapy, may be performed.

**Section Summary: Clinical Utility**
There are no studies that report direct evidence on the clinical utility of genetic testing for RTT. Thus, the clinical utility of genetic testing for RTT relies on whether a strong chain of evidence exists. For individuals with suspected RTT, identification of a pathogenic variant may alter patient management via increased surveillance of clinical manifestations such as scoliosis, cardiac arrhythmia, or autonomic dysfunction. The class or type of pathogenic may also impact disease severity, allowing for tailoring of ancillary treatments (e.g., occupational therapy) to maintain or improve functional outcomes (e.g., extremity mobility, ambulation).

**Targeted Familial Variant Testing of Asymptomatic Sisters of Individuals with Rett Syndrome**
**Clinical Context and Test Purpose**
The purpose of targeted familial variant testing of asymptomatic sisters of individuals with RTT is to predict the potential development of symptoms to determine the need for surveillance in young females and to aid in reproductive planning in females of reproductive age.

The relevant question addressed in this evidence review is: Does targeted familial variant testing of asymptomatic sisters of individuals with RTT lead to improved health outcomes, including changes in surveillance, preimplantation genetic testing to determine the likelihood of an affected offspring, or to informing reproductive planning decisions?

The following PICOTS were used to select literature to inform this review.
Patients
The relevant population of interest includes asymptomatic sisters of individuals with RTT.

Interventions
The relevant intervention of interest is targeted genetic testing for a known familial variant.

Comparators
The relevant comparator of interest is standard management without genetic screening.

Outcomes
The potential beneficial outcomes of primary interest would be confirming or excluding the need for surveillance in young females or changes in reproductive decision making in females of reproductive age. A negative genetic test result would eliminate the need for surveillance to detect development of symptoms and disease. A positive genetic test result has the potential to confirm a need for active surveillance and may inform reproductive decision making in reproductive-age patients.

Potential harmful outcomes are those resulting from a false-positive or false-negative test results. False-positive test results can lead to unnecessary surveillance (e.g., musculoskeletal or autonomic dysfunction) and treatments (e.g., spinal fusion for scoliosis or kyphosis). False-negative test results can lead to lack of appropriate surveillance and inaccurate risk assessment to determine the likelihood of an affected offspring.

Timing
The time frame for outcome measures varies from short-term development of an neurodevelopmental disorder in young females to long-term complications such as autonomic dysfunction, scoliosis or kyphosis, and growth retardation. In women of reproductive age, outcomes vary from short-term identification of subclinical or mild cognitive disorders to long-term birth of an affected offspring.

Setting
The primary setting would be in pediatric neurology or genetics outpatient offices for young female patients and in obstetrics, general practice, or genetics outpatient offices for female patients of reproductive age.

Analytic Validity
See the discussion of analytic validity in the Testing Individuals with Signs or Symptoms of Rett Syndrome section.

Clinical Validity
See the discussion of clinical validity in the Testing Individuals with Signs or Symptoms of Rett Syndrome section.

Clinical Utility
Direct evidence of the clinical utility for targeted genetic testing of a known familial variant in asymptomatic sisters is lacking. However, a chain of evidence can be constructed for targeted genetic testing to determine if sisters of affected child are asymptomatic or subclinical carriers of the known familial variant. The variable penetrance of disease due to random X inactivation in females as well as different classes or types of pathogenic variants leading to different disease severity suggest that targeted testing for a familial variant has potential clinical utility. In young sisters of an affected child, targeted testing for the known familial variant has potential clinical utility in identifying subclinical manifestations and eliminating or necessitating the need for surveillance of clinical manifestations of disease. In sisters of reproductive age, targeted testing can guide whether prenatal testing may be indicated and potentially alter reproductive decisions.
Targeted Testing of Females with a Child with Rett Syndrome Considering Further Childbearing
Clinical Context and Test Purpose
The purpose of targeted familial variant testing of females with a child with RTT who are considering having additional children is to determine carrier status and to aid in reproductive planning.

The relevant question addressed in this evidence review is: Does targeted familial variant testing of females with a child with RTT who are considering having additional children lead to improved health outcomes, including preimplantation genetic testing to determine likelihood of an affected offspring, or alter reproductive planning decisions?

The following PICOTS were used to select literature to inform this review.

Patients
The relevant population of interest includes female patients with a child with RTT.

Interventions
The relevant intervention of interest is targeted genetic testing for a known familial variant.

Comparators
The relevant comparator of interest is reproductive planning without genetic testing.

Outcomes
The potential beneficial outcomes of primary interest would be to determine carrier status to aid in reproductive decision making. A negative genetic test result would exclude a maternal inheritance of RTT and predict a low likelihood of an affected offspring derived from paternal inheritance. A positive genetic test result would predict a high likelihood of an affected offspring—a 50% chance of an hemizygous affected male or a 50% chance of an heterozygous affected female.

Potential harmful outcomes are those resulting from a false-positive or false-negative test results. False-positive test results can lead to reproductive decisions based on an incorrectly high prediction for an affected offspring. False-negative test results can lead to lack of appropriate preimplantation genetic diagnosis and inaccurate risk assessment to determine likelihood of an affected offspring.

Timing
The time frame for outcome measures varies from short-term (i.e., months) in the case of identification of seizures or subclinical or mild cognitive disorders, to long-term (i.e., decades), in the case of decision making about childbearing.

Setting
The primary setting would be in obstetrics, genetics, or general practitioner’s outpatient offices.

Analytic Validity
See the discussion of analytic validity in the Testing Individuals with Signs or Symptoms of Rett Syndrome section.

Clinical Validity
Sheikh et al (2016) analyzed pathogenic variants in hemizygous males. In heterozygous females, the variable phenotypic severity is modulated by nonrandom X inactivation, thus making genotype-phenotype comparisons unreliable. However, genotype-phenotype correlations in males with hemizygous MECP2 pathogenic variants can provide more accurate insights into the true biologic effect of specific pathogenic variant. A wide range of phenotypic/clinical severity was observed, ranging from neonatal encephalopathy to mild...
psychiatric abnormalities, with correlating functional and molecular results. Overall, clinical severity showed a direct correlation with the functional impairment of MeCP2.

Zahorakova et al (2016) analyzed RTT patients with MECP2 pathogenic variants and X-chromosome inactivation (XCI). Skewed XCI (ratio, >75%) was found in 19.3% of the girls, but no gross divergence in clinical severity was observed. Findings confirmed a high pathogenic variant frequency in classic RTT (92%) and a correlation between the MECP2 variant type and clinical severity. Additionally, limitations of XCI in explaining all of the phenotypic differences in RTT were noted.

**Section Summary: Clinical Validity**

Genotype-phenotype correlations in heterozygous females are confounded by both random XCI and the class or type of pathogenic variant present. In heterozygous females, the clinical sensitivity correlates with variant type and variable effects of skewed XCI. In contrast, for hemizygous males, the phenotypic / clinical severity of a particular pathogenic variant manifest completely.

**Clinical Utility**

Direct evidence of clinical utility for targeted genetic testing of a known familial variant in females with a child with RTT is lacking. However, a chain of evidence can be constructed for targeted genetic testing of a known familial variant to determine carrier status. The variable penetrance of disease due to random XCI in females as well as different classes or types of pathogenic variants leads to unpredictable disease severity. Although the majority of cases of RTT are due to de novo pathogenic variants in RTT-associated genes, determination of carrier status in a female with a child with RTT eliminates or necessitates prenatal testing and informs reproductive decision making. If a female tests negative for a known familial variant, future offspring are not at increased risk for RTT. In the rare situation where the mother carries a pathogenic variant, all future offspring have a 50% chance of being affected, with males typically presenting with more severe disease.

**Summary of Evidence**

For individuals who have signs and/or symptoms of Rett syndrome (RTT) who receive genetic testing for RTT-associated genes, the evidence includes case series and prospective cohort studies. Relevant outcomes are test accuracy and validity, other test performance measures, symptoms, health status measures, and quality of life. Methyl-CpG-binding protein 2 (MECP2) variants are found in most patients with RTT, particularly in those who present with classic clinical features of RTT. The diagnostic accuracy of genetic testing for RTT cannot be determined with absolute certainty given variable clinical presentations of typical versus atypical RTT, but testing appears to have high sensitivity and specificity. Genetic testing has clinical utility when signs and symptoms of RTT are present to establish a specific genetic diagnosis. Identification of a specific class or type of pathogenic variant may alter some aspects of management and may eliminate or necessitate surveillance for different clinical manifestations of disease. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

For individuals who are asymptomatic sisters of an individual with RTT who receive targeted genetic testing for a known familial RTT-associated variant, the evidence includes case series and prospective cohort studies. Relevant outcomes are test accuracy and validity, other test performance measures, changes in reproductive decision making, symptoms, and symptoms. Targeted familial variant testing of asymptomatic sisters can eliminate or necessitate surveillance given the variability of clinical presentation in girls’ due to X-chromosome inactivation and clinical severity based on the type of pathogenic variant present. In sisters of reproductive age, determination of carrier status can eliminate or necessitate prenatal testing and inform reproductive decision making. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.
For individuals who are females with a child with RTT who are considering future childbearing who receive targeted genetic testing for a known familial RTT-associated variant, the evidence includes case series and prospective cohort studies. Relevant outcomes are test accuracy and validity, other test performance measures, and changes in reproductive decision making. Targeted familial variant testing of a woman with a child with RTT to determine carrier status may inform prenatal testing and reproductive decision making. In the rare situation where the mother carries a pathogenic variant, all future offspring have a 50% risk of being affected, with males typically presenting with more severe disease. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

Supplemental Information

Clinical Input from Physician Specialty Societies and Academic Medical Centers

While the various physician specialty societies and academic medical centers 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 physician specialty societies or academic medical centers, unless otherwise noted.

In response to requests from Blue Cross Blue Shield Association, input on the use variant testing for Rett syndrome (RTT) was received from 2 specialty medical societies (3 reviewers) and 3 academic medical centers, for a total of 6 reviewers in 2012. There was consensus or near consensus supporting the use of variant testing for the diagnosis of RTT in a girl in whom the clinical differential diagnosis includes RTT, especially when clinical diagnosis is uncertain. Support for testing sisters of individuals with RTT and for prenatal screening was mixed.

Practice Guidelines and Position Statements

American Academy of Neurology and Child Neurology Society

In 2011, the American Academy of Neurology (AAN) and the Child Neurology Society (CNS) issued an evidence report on genetic and metabolic testing of children with global developmental delay. AAN and CNS recommended considering methyl-CpG-binding protein 2 (MECP2) genetic testing for all girls with unexplained moderate-to-severe developmental delay.

American Academy of Pediatrics

A 2007 policy statement from the American Academy of Pediatrics (AAP; reaffirmed in 2010) recommended MECP2 testing to confirm a diagnosis of suspected Rett syndrome (RTT), especially when the diagnosis was unclear from symptoms alone.

RettSearch

Neither AAN nor AAP has provided recommendations on when to use CDKL5 or FOXG1 testing. In 2010, RettSearch, a consortium of international clinical RTT specialists, suggested that patients who are negative for MECP2 variants and have a strong clinical diagnosis of RTT should be considered for further screening for the CDKL5 gene if there are early-onset seizures, or for the FOXG1 gene if there are congenital features (e.g., severe postnatal microcephaly).

American College of Medical Genetics and Genomics

In 2013, the American College of Medical Genetics and Genomics revised its evidence-based guidelines for clinical genetics evaluation of autism spectrum disorders. Testing for MECP2 genetic variants was recommended as part of the diagnostic workup of females who present with an autistic phenotype. Routine MECP2 testing in males with autistic spectrum disorders was not recommended.

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.

Ongoing and Unpublished Clinical Trials
Some currently unpublished trials that might influence this review are listed in Table 1.

Table 1. 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>Ongoing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCT01520363</td>
<td>Placebo Controlled Trial of Dextromethorphan in Rett Syndrome</td>
<td>60</td>
<td>Dec 2017</td>
</tr>
<tr>
<td>NCT02061137</td>
<td>A Phase 1 Clinical Study to Assess Safety and Efficacy of Oral Fingolimod (FTY720) in Children with Rett Syndrome</td>
<td>6</td>
<td>Jul 2018</td>
</tr>
<tr>
<td>NCT02171104</td>
<td>MT2013-31: Allogeneic Hematopoietic Cell Transplantation for Inherited Metabolic Disorders and Severe Osteopetrosis Following Conditioning with Busulfan (Therapeutic Drug Monitoring), Fludarabine +/- ATG</td>
<td>100</td>
<td>Sep 2019</td>
</tr>
<tr>
<td>Unpublished</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCT00990691</td>
<td>Pilot Study of the Effects of Desipramine on the Neurovegetative Parameters of the Child with Rett Syndrome</td>
<td>36</td>
<td>Dec 2014 (completed)</td>
</tr>
<tr>
<td>NCT02023424</td>
<td>An Open Label, Exploratory Study to Investigate the Treatment Effect of Glatiramer Acetate (Copaxone®) on Girls with Rett Syndrome</td>
<td>10</td>
<td>Feb 2015 (unknown)</td>
</tr>
<tr>
<td>NCT02153723</td>
<td>Pharmacological Treatment of Rett Syndrome with Glatiramer Acetate (Copaxone)</td>
<td>20</td>
<td>Jun 2015 (unknown)</td>
</tr>
<tr>
<td>NCT01777542</td>
<td>Pharmacological Treatment of Rett Syndrome by Stimulation of Synaptic Maturation with Recombinant Human IGF-1(Mecasermin [rDNA] Injection)</td>
<td>30</td>
<td>Nov 2016 (completed)</td>
</tr>
</tbody>
</table>

NCT: national clinical trial.

Appendix

Appendix Table 1. Categories of Genetic Testing Addressed in 2.04.81

<table>
<thead>
<tr>
<th>Category</th>
<th>Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Testing of an affected individual's germline to benefit the individual</td>
<td></td>
</tr>
<tr>
<td>1a. Diagnostic</td>
<td>X</td>
</tr>
<tr>
<td>1b. Prognostic</td>
<td></td>
</tr>
<tr>
<td>1c. Therapeutic</td>
<td></td>
</tr>
<tr>
<td>2. Testing cancer cells from an affected individual to benefit the individual</td>
<td></td>
</tr>
<tr>
<td>2a. Diagnostic</td>
<td></td>
</tr>
<tr>
<td>2b. Prognostic</td>
<td></td>
</tr>
<tr>
<td>2c. Therapeutic</td>
<td></td>
</tr>
<tr>
<td>3. Testing an asymptomatic individual to determine future risk of disease</td>
<td>X</td>
</tr>
<tr>
<td>4. Testing of an affected individual's germline to benefit family members</td>
<td></td>
</tr>
<tr>
<td>5. Reproductive testing</td>
<td></td>
</tr>
<tr>
<td>5a. Carrier testing: preconception</td>
<td>X</td>
</tr>
<tr>
<td>5b. Carrier testing: prenatal</td>
<td>X</td>
</tr>
<tr>
<td>5c. In utero testing: aneuploidy</td>
<td></td>
</tr>
<tr>
<td>5d. In utero testing: familial variants</td>
<td></td>
</tr>
<tr>
<td>5e. In utero testing: other</td>
<td></td>
</tr>
<tr>
<td>5f. Preimplantation testing with in vitro fertilization</td>
<td></td>
</tr>
</tbody>
</table>

References


### Documentation for Clinical Review

**Please provide the following documentation (if/when requested):**

- History and physical and/or consultation notes including:
  - Reason for performing test
  - Signs/symptoms/test results related to reason for genetic testing
  - Family history if applicable
  - How test result will impact clinical decision making
- Lab results documenting one/both partners carrier status or genetic disorder
- Physician order for genetic test
- Name and description of genetic test
- CPT codes billed for the particular genetic test

### Post Service

- Procedure report(s)

### Coding

This Policy relates only to the services or supplies described herein. Benefits may vary according to benefit design; therefore, contract language should be reviewed before applying the terms of the Policy. Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement.

**MN/IE**

The following services may be considered medically necessary in certain instances and investigational in others. Services may be considered medically necessary when policy criteria are met. Services may be considered investigational when the policy criteria are not met or when the code describes application of a product in the position statement that is investigational.

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPT®</td>
<td>81302</td>
<td>MECP2 (methyl CpG binding protein 2) (e.g., Rett syndrome) gene analysis; full sequence analysis</td>
</tr>
<tr>
<td>CPT®</td>
<td>81303</td>
<td>MECP2 (methyl CpG binding protein 2) (e.g., Rett syndrome) gene analysis; known familial variant</td>
</tr>
<tr>
<td>CPT®</td>
<td>81304</td>
<td>MECP2 (methyl CpG binding protein 2) (e.g., Rett syndrome) gene analysis; duplication/deletion variants</td>
</tr>
</tbody>
</table>
### Table

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>81404</td>
<td>Molecular pathology procedure, Level 5</td>
</tr>
<tr>
<td></td>
<td>81406</td>
<td>Molecular pathology procedure, Level 7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HCPCS</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICD-10 Procedure</td>
<td>None</td>
</tr>
<tr>
<td>ICD-10 Diagnosis</td>
<td>All Diagnoses</td>
</tr>
</tbody>
</table>

### Definitions of Decision Determinations

**Medically Necessary:** A treatment, procedure, or drug is medically necessary only when it has been established as safe and effective for the particular symptoms or diagnosis, is not investigational or experimental, is not being provided primarily for the convenience of the patient or the provider, and is provided at the most appropriate level to treat the condition.

**Investigational/Experimental:** A treatment, procedure, or drug is investigational when it has not been recognized as safe and effective for use in treating the particular condition in accordance with generally accepted professional medical standards. This includes services where approval by the federal or state governmental is required prior to use, but has not yet been granted.

**Split Evaluation:** Blue Shield of California/Blue Shield of California Life & Health Insurance Company (Blue Shield) policy review can result in a split evaluation, where a treatment, procedure, or drug will be considered to be investigational for certain indications or conditions, but will be deemed safe and effective for other indications or conditions, and therefore potentially medically necessary in those instances.

### Prior Authorization Requirements (as applicable to your plan)

Within five days before the actual date of service, the provider must confirm with Blue Shield that the member's health plan coverage is still in effect. Blue Shield reserves the right to revoke an authorization prior to services being rendered based on cancellation of the member's eligibility. Final determination of benefits will be made after review of the claim for limitations or exclusions.

Questions regarding the applicability of this policy should be directed to the Prior Authorization Department. Please call (800) 541-6652 or visit the provider portal at www.blueshieldca.com/provider.

**Disclaimer:** This medical policy is a guide in evaluating the medical necessity of a particular service or treatment. Blue Shield of California may consider published peer-reviewed scientific literature, national guidelines, and local standards of practice in developing its medical policy. Federal and state law, as well as contract language, including definitions and specific contract provisions/exclusions, take precedence over medical policy and must be considered first in determining covered services. Member contracts may differ in their benefits. Blue Shield reserves the right to review and update policies as appropriate.