PTEN Hamartoma Tumor Syndromes Testing

Procedures addressed

The inclusion of any procedure code in this table does not imply that the code is under management or requires prior authorization. Refer to the specific Health Plan’s procedure code list for management requirements.

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What is PTEN hamartoma tumor syndrome

Definition

PTEN hamartoma tumor syndrome (PHTS) is used to describe the group of conditions caused by PTEN mutations that include hamartomatous growths: Cowden syndrome, Bannayan-Riley-Ruvalcaba syndrome, Proteus syndrome and Proteus-like syndrome, and autism spectrum disorder with macrocephaly.

- Historically, these conditions have been considered clinically distinct but share an underlying genetic etiology, and show some overlap in families.¹
  
  - **Cowden syndrome** (CS) is characterized by an increased risk for benign and malignant tumors of the breast, endometrium, and thyroid (non-medullary).¹,² Other common features include macrocephaly and growths on the skin or mucous membranes (mucocutaneous lesions). Prevalence is estimated to be 1 in 200,000 individuals, although CS is believed to be underdiagnosed.¹ Up to 80% of people with a clinical diagnosis of CS have a PTEN mutation in the coding region.¹ Ten percent of individuals with CS have a PTEN mutation in the promoter region.¹
  
  - **Lhermitte-Duclos disease** (LDD) is a rare, benign tumor of the cerebellum called dysplastic gangliocytoma that may present in childhood or adulthood.¹,² Most adult-onset LDD is caused by a PTEN mutation even when no other signs of CS are present.¹
  
  - **Bannayan-Riley-Ruvalcaba syndrome** (BRRS) is a genetic disorder characterized by macrocephaly, multiple benign intestinal polyps
(hamartomatous type), lipomas, colored spots on the tip of the penis (pigmented macules of the glans penis), and hemangiomas. Some people with BRRS have intellectual disability and/or birth defects. There may be an increased risk for several types of cancer, including breast, thyroid and endometrial. Up to 71% of people with a clinical diagnosis of BRRS have a PTEN mutation.

- **Proteus and Proteus-like syndromes** are highly variable conditions characterized by overgrowth of several different tissues usually in a patchy asymmetric pattern (mosaic) that is often present from birth but gets worse over time.
  
  Clinical signs and symptoms include connective tissue and epidermal nevi (hamartomatous growths), ovarian cystadenomas, parotid monomorphic adenomas, lipomas, capillary/venous/lymphatic malformations, and a characteristic facial dysmorphology. Up to 50% of people with Proteus-like syndrome and 20% of people with Proteus syndrome have a PTEN mutation.

- **Autism spectrum disorder with macrocephaly**, defined as >2.5 SDs above the age mean or ≥97th percentile, may be caused by a mutation in the PTEN gene. An estimated 3-20% of all people with ASD/macrocephaly have a PTEN mutation. The likelihood may be greater if other family members have signs and symptoms in the PHTS spectrum.

- An online tool is available to estimate the likelihood of identifying a PTEN mutation based on clinical findings: [http://www.lerner.ccf.org/gmi/ccscore/](http://www.lerner.ccf.org/gmi/ccscore/).

- People with CS need heightened cancer surveillance starting at age 18 (or earlier if warranted: "For those with a family history of a particular cancer type at an early age screening may be initiated five to ten years prior to the youngest diagnosis in the family") The exception is children should have a yearly thyroid ultrasound from the time of diagnosis and skin check with physical examination. Because of the overlap in clinical phenotypes, people with other PTEN-related conditions are advised to follow the same heightened cancer surveillance guidelines as for CS.

- The lifetime risk for breast cancer is 25-50% with an average age at diagnosis of 38-46 years. However, a 2012 publication by Tan et al. reports that this lifetime risk may be as high as 85%, particularly in individuals with PTEN promoter mutations. The lifetime risk for thyroid cancer can range from 10% to as high as 35%. Benign thyroid growths are also found in up to 75% of people with CS. “However, the high frequency of thyroid disease in the general population means that when taken on their own, thyroid neoplasms have a low predictive value for identifying mutations carriers.”

- Endometrial cancer has an estimated 5-10% lifetime risk, although this is not well-defined. Tan et al. reports a lifetime risk of up to 28%.

- The gastrointestinal polyp risk (often colonic) in patients with CS may be 80% or higher and the lifetime risk for colorectal cancer is estimated to be 9%.
Early onset colorectal cancer has been reported in 13% of patients with PTEN associated CS indicating earlier and more frequent colonoscopy is warranted in this population.6,8,9

Additionally, an increased lifetime risk for kidney cancer (approximately 34%) and melanoma (about 5-6%) has been reported.1,2,6

PTEN mutations are inherited in an autosomal dominant manner, meaning that a person only needs a mutation in one copy of the gene to be affected. A child of an affected person has a 50% chance to inherit the mutation. Nearly all people with a PTEN mutation will develop symptoms (complete penetrance).1,2

**Test information**

- **PTEN Sequencing**: Evaluates each DNA nucleotide to identify mutations throughout the gene. Such testing will detect a mutation in about 80% of people with a clinical diagnosis of CS and 60% of people with a clinical diagnosis of BRRS.1

  - Sequencing of the promoter region will detect an additional 10% of PTEN mutations that cause CS.1 NCCN recommends comprehensive testing, which should include full sequencing, gene deletion/duplication analysis, and promoter analysis of the PTEN gene.2 As such, it is important to determine whether or not the selected laboratory includes PTEN promoter analysis in their testing.2

- **PTEN Deletion/Duplication Analysis**: Used in cases where a mutation is not found by sequencing. The likelihood of identifying a deletion or duplication in people with clinically diagnosed CS is unknown, but expected to be relatively low.1 About 11% of people with BRRS have large PTEN gene deletions.1

- **PTEN Known Familial Mutation Analysis**: Once the familial mutation is identified, testing for that one mutation can be offered to at-risk relatives. Such testing is much less expensive than complete gene testing and the results are highly reliable.

**Guidelines and evidence**

- Evidence-based guidelines (Category 2A) from the National Comprehensive Cancer Network (NCCN, 2018) support the use of PTEN genetic testing in those with clinical features or a family history. They recommend PTEN genetic testing in any of the following situations:2

  - Family history of a known PTEN mutation [PTEN known familial mutation testing is appropriate]

  - A personal history of any of the following:

    - Bannayan-Riley-Ruvalcaba syndrome (BRRS)
- Adult-onset Lhermitte Duclos disease (cerebellar dysplastic gangliocytoma)
- Autism spectrum disorder and macrocephaly (greater than or equal to 97th percentile)
- Two or more biopsy proven trichilemmomas
- Macrocephaly and at least one other major** criteria
- Three major** criteria without macrocephaly
- One major** and three or more minor*** criteria
- Four or more minor*** criteria

- At-risk relative of someone clinically diagnosed with Cowden syndrome or BRRS (who has not had genetic testing), when the at-risk relative has at least one major** or two minor*** criteria. Ideally, the at-risk person is a first-degree relative (parent, sibling, child) of someone clinically diagnosed, but testing more distant relatives is acceptable if closer relatives are not available or willing to have testing.

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<thead>
<tr>
<th><strong>Major:</strong></th>
<th>*<strong>Minor:</strong></th>
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<tr>
<td>Breast cancer</td>
<td>Autism spectrum disorder</td>
</tr>
<tr>
<td>Endometrial cancer</td>
<td>Colon cancer</td>
</tr>
<tr>
<td>Follicular thyroid cancer</td>
<td>3 or more esophageal glycogenic acanthoses</td>
</tr>
<tr>
<td>Multiple GI hamartomas or</td>
<td>Lipomas</td>
</tr>
<tr>
<td>ganglioneuromas</td>
<td>Intellectual disability (IQ less than or equal to 75)</td>
</tr>
<tr>
<td>Macrocephaly (at least 97\textsuperscript{th} percentile: 58cm in adult women and 60cm in adult men)</td>
<td>Papillary or follicular variant of papillary thyroid cancer</td>
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<td>Macular pigmentation of glans penis</td>
<td>Thyroid structural lesions (e.g., adenoma, nodule(s), goiter)</td>
</tr>
<tr>
<td>Mucocutaneous lesions: one</td>
<td>Renal cell carcinoma</td>
</tr>
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<td>biopsy-proven trichilemmoma, multiple palmoplantar keratoses, multifocal or extensive oral mucosal papillomatosis, multiple cutaneous facial papules (often verrucous)</td>
<td>Single GI hamartoma or ganglioneuroma</td>
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<td>Testicular lipomatosis</td>
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<td></td>
<td>Vascular anomalies (including multiple intracranial developmental venous anomalies)</td>
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Note  These NCCN defined major and minor criteria for genetic testing do not fully align with the major and minor criteria required for a clinical diagnosis.

- The American College of Medical Genetics and Genomics (ACMG, 2008) issued consensus practice guidelines on the genetics evaluation of autism. They propose an evaluation scheme with three tiers. The first tier includes routine studies such as chromosome analysis and fragile X genetic testing. PTEN gene testing is recommended as a second tier test when the head circumference is greater than 2.5 SDs above the mean (if no diagnosis is made via first tier testing).  

- An expert-authored review (2014) of the PTEN hamartoma syndromes states:
  - “The diagnosis of PHTS is made only when a PTEN mutation is identified.”
  - “The appropriate order of PTEN testing to optimize yield:”
    - i. “Sequence all PTEN coding exons 1-9 and flanking intronic regions. If no pathogenic variant is identified, perform:”
    - ii. “Deletion/duplication analysis. If no pathogenic variant is identified, consider:”
    - iii. “Sequence analysis of the promoter region for variants that decrease gene expression”
  - “The most serious consequences of PHTS relate to the increased risk of cancers including breast, thyroid, endometrial, and to a lesser extent, renal. In this regard, the most important aspect of management of any individual with a PTEN pathogenic variant is increased cancer surveillance to detect any tumors at the earliest, most treatable stages.”

Criteria
PTEN gene testing may be considered in individuals with a suspected or known clinical diagnosis of Cowden syndrome, Bannayan-Riley-Ruvalcaba syndrome (BRRS), or another PTEN-related hamartoma syndrome; or who have a known family history of a PTEN mutation.

PTEN Known Familial Mutation Analysis

- Genetic Counseling:
  - Pre and post-test genetic counseling by an appropriate provider (as deemed by the Health Plan policy), AND
- Previous Testing:
  - No previous genetic testing of PTEN, AND
- Diagnostic and Predisposition Testing:
Known deleterious family mutation in PTEN identified in 1st, 2nd, or 3rd degree biologic relative(s), AND

• Rendering laboratory is a qualified provider of service per the Health Plan policy.

PTEN Sequencing with promoter analysis

• Genetic Counseling:
  o Pre and post-test genetic counseling by an appropriate provider (as deemed by the Health Plan policy), AND

• Previous Testing:
  o No previous genetic testing of PTEN, AND

• Diagnostic Testing for Symptomatic Individuals
  o Personal history of ANY of the following:
    ▪ Bannayan Riley-Ruvalcaba syndrome; or
    ▪ Adult Lhermitte-Duclos disease (LDD); or
    ▪ Autism spectrum disorder and macrocephaly; or
    ▪ At least two biopsy-proven trichilemmomas; or
    ▪ At least two major criteria** (one must be macrocephaly); or
    ▪ Three major criteria** without macrocephaly; or
    ▪ One major** and at least three minor criteria***; or
    ▪ Four or more minor criteria***, OR

• Predisposition testing for Presymptomatic/Asymptomatic Individuals:
  o At-risk person with a family history of:
    ▪ A relative (includes first-degree relative or more distant relatives if the first-degree relative is unavailable or unwilling to be tested ) with a clinical diagnosis of Cowden syndrome or BRR (no previous genetic testing); and
    ▪ One major** OR two minor criteria*** in the at-risk person, AND

• Rendering laboratory is a qualified provider of service per the Health Plan policy.

PTEN Deletion/Duplication Analysis:

• Genetic Counseling:
o Pre and post-test genetic counseling by an appropriate provider (as deemed by
the Health Plan policy), AND

• Previous Testing:
  o Sequence analysis of PTEN has been performed and resulted negative, and
  o No previous deletion/duplication testing, AND

• Rendering laboratory is a qualified provider of service per the Health Plan policy.

Criteria for testing purposes are: ²

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