

## **Clinical Appropriateness Guidelines**

# Genetic Testing for Reproductive Carrier Screening and Prenatal Diagnosis

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# Scope

This document addresses genetic testing in the reproductive setting, including both testing of parents (carrier screening) and testing of fetal or embryonic DNA (prenatal diagnosis, preimplantation genetic testing, cell-free DNA).

## Appropriate Use Criteria

### Carrier Screening for Familial Disease

Single gene reproductive carrier screening is medically necessary when any of the following criteria are met:

- An individual's reproductive partner is a known carrier of a disease-causing mutation for a recessively-inherited condition
- A diagnosis of a genetic disorder has been confirmed in an affected relative, and one of the following:
  - a genetic mutation has been identified
  - the affected relative has not had genetic testing and is unavailable for testing

### Fragile X

Preconception or prenatal genetic testing for Fragile X syndrome (FMR1) is medically necessary for the following indications:

- Family history of unexplained intellectual disability/developmental delay or autism in a blood relative
- Personal or family history of premature ovarian insufficiency

### Carrier Screening for Common and Ethnic Genetic Diseases

#### *Cystic Fibrosis*

Cystic fibrosis (CF) carrier screening with a targeted test for common variants (CPT code 81220) is medically necessary when testing has not been previously performed.

#### *Spinal Muscular Atrophy*

Spinal muscular atrophy (SMA) carrier screening by SMN1 gene dosage analysis is medically necessary when testing has not been previously performed.

- For those with a family history of SMA, pre- and post-test genetic counseling is recommended to discuss testing strategy due to the complex inheritance of this condition. For those with abnormal or inconclusive results, post-test genetic counseling is recommended.

## ***Hemoglobinopathies***

Hemoglobinopathy genetic carrier screening (common deletions or variants in genes HBB, HBA1, or HBA2 for thalassemias, sickle cell disease) is medically necessary when any of the following criteria are met:

- Clinical or laboratory features (e.g. CBC, hemoglobin electrophoresis) are suggestive of a hemoglobinopathy
- Results of testing by conventional studies (e.g., electrophoresis, liquid chromatography, isoelectric focusing) yield equivocal results
- A definitive diagnosis remains uncertain or a definitive diagnosis is known but specific mutation identification is necessary for prenatal diagnosis

## ***Ashkenazi Jewish Carrier Screening***

Ashkenazi Jewish carrier screening by targeted mutation analysis for the following conditions is medically necessary when an individual or their reproductive partner has Ashkenazi Jewish ancestry:

- Familial dysautonomia
- Tay Sachs disease
- Canavan disease
- Fanconi anemia group C
- Niemann-Pick disease, type A
- Bloom syndrome
- Mucopolysaccharidosis type IV
- Gaucher disease, type 1

## **Carrier Screening Not Clinically Appropriate**

The following tests are not medically necessary for carrier screening in the general population:

- Universal carrier screening panels
- Full gene sequencing when targeted mutation testing of common variants is available
- Whole exome sequencing
- Additional conditions/genes not mentioned above

## **Preimplantation Genetic Screening and Diagnostic Testing of Embryos (PGD)**

Note: Coverage of genetic testing of embryos may be dependent upon health plan fertility benefits.

Preimplantation genetic diagnosis (PGD), including the embryo biopsy procedure if applicable, is medically necessary for the following indications:

- Both biologic parents are carriers of a single gene autosomal recessively-inherited disorder

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- One of the biologic parents is a known carrier of a single gene autosomal dominantly-inherited disorder or a single X-linked disorder
- One biologic parent is a carrier of a chromosomal rearrangement
- A previous pregnancy or child has been diagnosed with a genetic disease and familial mutation(s) are known

PGD is not medically necessary for any other indication, including but not limited to the following:

- human leukocyte antigen (HLA) typing of an embryo to identify a future suitable stem-cell tissue or organ transplantation donor
- testing solely to determine if an embryo is a carrier of an autosomal recessively-inherited disorder
- testing for a multifactorial condition
- testing for variants of unknown significance
- nonmedical gender selection
- nonmedical traits

### **Preimplantation Genetic Screening for Common Aneuploidy (PGS)**

Preimplantation genetic screening of common aneuploidy by any testing methodology is not medically necessary for any indication, including but not limited to the following:

- advanced maternal age (i.e., age  $\geq$  35 years)
- repeated in vitro fertilization (IVF) failures
- recurrent spontaneous abortions

### **Prenatal Cell-Free DNA Screening**

Prenatal cell-free DNA screening (cfDNA) (CPT codes 81507 or 81420) is medically necessary if all of the following criteria are met:

- single gestation pregnancy
- gestational age  $\geq$ 10 weeks

Prenatal cell-free DNA screening is not medically necessary for the following indications:

- multiple gestation pregnancies
- cases with a known co-twin demise (vanishing twin syndrome)
- miscarriage or fetal demise

The following tests are experimental, investigational or unproven:

- screening for microdeletions (e.g. 22q11.2, Cri-du-chat, whole genome, etc.)
- screening for autosomal trisomies other than 13, 18, and 21
- prenatal cell-free DNA testing for single gene conditions

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Concurrent screening for aneuploidy using multiple screening tests is not considered medically necessary.

### **Invasive Prenatal Testing of a Fetus**

Invasive prenatal genetic testing is medically necessary when the results of the genetic test will impact clinical decision-making and the requested method is scientifically valid for the suspected condition.

### **Reproductive Genetic Testing for Recurrent Pregnancy Loss**

Genetic tests to evaluate for the presence of a chromosome rearrangement are medically necessary for the evaluation of recurrent pregnancy loss (i.e., two or more unexplained pregnancy losses).

The following genetic tests for the evaluation of recurrent pregnancy loss are experimental, investigational or unproven:

- F2
- F5
- MTHFR

### **Reproductive Genetic Testing for the Diagnosis of Infertility**

The following tests are medically necessary when performed to establish the underlying etiology of infertility:

- Cystic fibrosis testing for males with either congenital bilateral absence of vas deferens or azoospermia or severe oligospermia (i.e., < five million sperm/millimeter) with palpable vas deferens
- Karyotyping for chromosomal abnormalities in males with nonobstructive azoospermia or severe oligospermia (i.e., < five million sperm/millimeter)
- Y-chromosome microdeletion testing in males with nonobstructive azoospermia or severe oligospermia (i.e., < five million sperm/millimeter)

(See above for Fragile X testing criteria related to premature ovarian insufficiency.)

# CPT Codes

The following codes are associated with the the guidelines outlined in this document. This list is not all inclusive.

- 81220 CFTR (cystic fibrosis transmembrane conductance regulator)(eg, cystic fibrosis) gene analysis; common variants (eg, ACMG/ACOG guidelines)
- 81420 Fetal chromosomal aneuploidy(eg, trisomy 21, monosomy X) genomic sequence analysis panel, circulating cell-free fetal DNA in maternal blood, must include analysis of chromosomes 13, 18, and 21
- 81507 Fetal aneuploidy (trisomy 21, 18, and 13) DNA sequence analysis of selected regions using maternal plasma,algorithm reported as a risk score for each trisomy
- 81422 Fetal chromosomal microdeletion(s) genomic sequence analysis (eg, DiGeorge syndrome, Cri-du-chat syndrome), circulating cell-free fetal DNA in maternal blood
- 81243 FMR1 (fragile X mental retardation 1) (eg, fragile X mental retardation) gene analysis; evaluation to detect abnormal (eg, expanded) alleles
- 81244 FMR1 (fragile X mental retardation 1) (eg, fragile X mental retardation) gene analysis; characterization of alleles (eg, expanded size and methylation status)
- 81400 SMN1 (survival of motor neuron 1, telomeric) (eg, spinal muscular atrophy), exon 7 deletion
- 81401 SMN1/SMN2 (survival of motor neuron 1, telomeric/survival of motor neuron 2, centromeric) (eg, spinal muscular atrophy), dosage analysis (eg, carrier testing)
- 81412 Ashkenazi Jewish associated disorders (eg, Bloom syndrome, Canavan disease, cystic fibrosis, familial dysautonomia, Fanconi anemia group C, Gaucher disease, Tay-Sachs disease), genomic sequence analysis panel, must include sequencing of at least 9 genes, including ASPA, BLM, CFTR, FANCC, GBA, HEXA, IKBKAP, MCOLN1, and SMPD1

## Background

### Reproductive Carrier Screening

Carrier screening in the prenatal or preconception period is recommended for a variety of conditions based upon ethnic background and family history. Certain autosomal recessive disease conditions are more prevalent in individuals of specific ancestry and, thus, these couples are at increased risk for having offspring with one of these conditions. Some of these conditions may be lethal in childhood or are associated with significant morbidity.

Carrier screening for cystic fibrosis is recommended by the American College of Obstetrics and Gynecology (ACOG) for individuals in the preconception and prenatal periods regardless of ethnic background or family history. ACOG's current recommendations indicate that complete sequencing of the CFTR gene is not appropriate for routine carrier screening, but carrier screening panels should include at minimum the 23 most common mutations(ACOG 2017). The American College of Medical

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Genetics and ACOG also recommend preconception and prenatal screening for spinal muscular atrophy (SMA) regardless of family history. Fragile X carrier screening is recommended for women with a family history of fragile X-related disorders, unexplained mental retardation or developmental delay, autism, or premature ovarian insufficiency (ACOG 2017). Currently Fragile X carrier screening in the general population is not routinely recommended.

Individuals of Ashkenazi Jewish descent have an increased risk to have a child with certain autosomal recessive conditions. The American College of Medical Genetics (ACMG) recommends carrier screening for cystic fibrosis, Canavan disease, familial dysautonomia, Tay-Sachs disease, Fanconi anemia (Group C), Niemann-Pick (Type A), Bloom syndrome, mucopolidosis IV, and Gaucher disease for all Ashkenazi Jews who are pregnant or considering pregnancy. These disorders all have significant health impact on an affected infant. When only one member of a couple has Jewish ancestry, carrier screening is still recommended. However, these couples should be made aware that it may be difficult to accurately predict the risk of affected offspring as the detection rate and carrier frequency for non-Jewish individuals is unknown for the majority of these conditions (ACOG 2017).

Recently, large pan-ethnic expanded carrier screening panels have become available. These panels typically include targeted mutation analysis or sequencing of hundreds of genes and are intended to be used for general population carrier screening. There are no standard guidelines regarding which disease genes and mutations to include on an expanded carrier screening panel. These panels typically include both diseases that are present with increased frequency in specific populations, but also a large number of diseases for which any given individual is not at high risk of being a carrier without a known family history. There is limited evidence regarding the clinical utility of this broad carrier screening approach in reducing the incidence of these rare genetic disorders. Multiple professional societies have called for guidelines to be developed that would limit genes on these panels based on standard criteria, such as only including severe, childhood-onset genetic diseases, and only genes for which mutation frequencies are known and prognosis can be predicted based on genotype (Grody 2013, Edwards 2015). The recent ACOG committee opinion 690 gives the following suggestions for conditions to include on expanded carrier screening panels: a carrier frequency of 1 in 100 or greater, a well-defined phenotype, a detrimental effect on quality of life, cause cognitive or physical impairment, require surgical or medical intervention, and disease onset early in life.

## Preimplantation Genetic Diagnosis

Preimplantation genetic diagnosis (PGD) is a procedure that involves testing an embryo for a genetic condition before the embryo is placed into the uterus for implantation. PGD is available for a variety of single gene conditions and chromosome rearrangements, but requires the following:

- Genetic testing on one or both parents: the diagnosis in the family needs to be confirmed via genetic testing and the specific causative variant(s) must be known
- In Vitro Fertilization (IVF): PGD can only be done in the context of IVF

Methods used for PGD vary, and may depend on the specific type of mutation or chromosome change. Linkage analysis is still required in many cases despite advances in testing methodologies.

## Preimplantation Aneuploidy Screening

Preimplantation genetic screening (PGS) of involves testing for chromosome abnormalities in biopsied cells from IVF-created embryos. Historically, PGS was performed using FISH for common aneuploidies on single cells from cleavage stage embryos; however, microarray technology has become more common in the last few years, as has testing multiple cells from the trophectoderm at the blastocyst

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stage (Brezina et al., 2016). Microarray allows testing for aneuploidies in all 23 chromosomes, but cannot detect triploidy. Many other technical methods (e.g. qPCR) are used or are in development for PGS.

Despite these advances, multiple researchers have called into question the accuracy of testing trophoctoderm biopsies to determine the aneuploid status of an embryo due to the apparent frequency of mosaicism (Maxwell et al., 2016; Gleicher & Orvieto, 2017). Trophoctoderm mosaicism has been reported to be as high as 70-90% in cleavage- and blastocyst-stage embryos, and increasing evidence suggests that this may be a normal phenomenon. Therefore, using PGS to eliminate embryos with detected chromosome abnormalities in the trophoctoderm may in fact lead to discarding embryos that still have the potential to develop into healthy, liveborn infants. Munne et al. (2017) determined that about 40% of embryos with mosaic results from PGS can result in viable, healthy pregnancies.

Studies evaluating the effectiveness of PGS include prospective nonrandomized and randomized controlled trials. While several small studies suggest that PGS outcomes may be improving, there is no consensus about when to use the technology or for which populations. Published, peer-reviewed scientific literature does not support the use of PGS in couples undergoing IVF procedures for infertility with a history of recurrent pregnancy loss, repeated IVF failures and/or advanced maternal age in order to improve IVF success rates. At this time, there is not enough evidence to suggest that PGS is medically necessary to improve fertility outcomes (ACOG 2009).

## **Prenatal Cell-Free DNA Testing**

Prenatal cell-free DNA tests, also called non-invasive prenatal tests (NIPT), are highly sensitive DNA sequencing-based tests that screen for common fetal aneuploidy, including trisomy 21/18/13 and sex chromosome abnormalities. NIPT, which tests a maternal blood sample, may be used as a sophisticated screening test to help determine who might benefit from invasive diagnostic testing for fetal aneuploidy using chorionic villus sampling (CVS) or amniocentesis.

NIPT for trisomies 13,18 and 21 has a significantly higher testing performance than traditional prenatal aneuploidy screening tests (e.g. maternal serum screening). Specific sensitivity and specificity is somewhat condition-dependent but typically reported as greater than 95-99%. While NIPT has a higher false-positive rate and a lower positive predictive value (ACOG 2015) for the average-risk pregnancy, validation studies have indicated that it has superior performance compared with traditional maternal serum screening and national guidelines have recently begun to recommend expanded use of the test. In a 2015 Committee Opinion, the American College of Obstetrics and Gynecologists acknowledge that any woman may choose to have NIPT, just as any woman may choose to have invasive diagnostic testing. In 2016, the American College of Medical Genetics reiterated its stance that NIPT should be available to women of all risk groups as one of many options. The Society for Maternal Fetal Medicine, however, states that the best candidates for NIPT are those at high risk for aneuploidy (2015).

Several laboratories have added common microdeletions such as 22q11.2 to their NIPT testing platforms, and some labs now offer evaluation of cell free DNA for copy number changes greater than 7Mb across the genome. Cell-free DNA microdeletion studies have not been clinically validated and are not recommended by the American College of Obstetrics and Gynecologists, the European and American Societies for Human Genetics, or the Society for Maternal Fetal Medicine (ACOG 2016, Dondorp 2015, SMFM 2016).

Several large validation studies have demonstrated the sensitivity and specificity of NIPT for determining fetal sex in addition to common chromosome abnormalities. These studies have indicated

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that screening for XY chromosome aneuploidy has a significantly lower positive predictive value than other chromosomes (ACOG 2016). In addition, the phenotype associated with these conditions is highly variable. This has led both the European and the American Societies of Human Genetics to issue recommendations that sex chromosome screening by cfDNA not be performed (Dondorp 2015), and the American College of Medical Genetics recommends that patients should be discouraged from choosing screening for the sole purpose of fetal sex determination (Gregg 2016).

## **Prenatal Diagnosis via Karyotype, Microarray, or Exome Sequencing**

The American College of Obstetricians and Gynecologists (ACOG) recommends prenatal CMA on CVS or amniocentesis samples for patients with a fetus with one or more major structural abnormalities identified on ultrasonographic examination. They also state that in patients with a structurally normal fetus undergoing invasive prenatal diagnostic testing, either fetal karyotyping or a chromosomal microarray analysis can be performed (regardless of maternal age). Microarray is also recommended in place of karyotype for the genetic evaluation of intrauterine fetal demise or stillbirth, because of its greater ability to obtain results from dead tissue. ACOG does not recommend routine CMA analysis on structurally normal pregnancy losses less than 20 weeks gestation.

Recently, some laboratories have begun offering whole exome sequencing tests for the purpose of prenatal diagnosis in cases of fetal anomalies that remain unexplained after standard genetic workups. Published data regarding the use of this test in a prenatal setting have been limited to case reports and small cohorts. There are select circumstances in which prenatal WES may be a useful diagnostic tool, such as recurrent, lethal fetal anomalies for which other testing has been uninformative. However, limitations of WES in a prenatal setting include long turnaround times and high rates of variants of unknown significance, which are especially difficult to interpret for ongoing pregnancies without the ability to perform a full physical examination of the fetus. The routine use of prenatal exome sequencing is not recommended outside of clinical trials (ACOG/SMFM 2016).

## **Recurrent Pregnancy Loss Testing**

The American College of Obstetricians and Gynecologists (ACOG) and the American Society for Reproductive Medicine (ASRM) both recommend chromosomal analysis via karyotyping when a couple has a history of recurrent pregnancy loss (two or more unexplained losses). Karyotypic analysis can be performed on either the products of conception or on both parents when a history of recurrent pregnancy loss is identified. The American College of Medical Genetics states that chromosomal microarray (CMA) should NOT be used to evaluate parents with a history of recurrent pregnancy loss, as this technology cannot detect balanced chromosomal rearrangements.

See Pharmacogenetic and Thrombophilia Testing Guideline for discussion of F5, F2, and MTHFR testing.

## **Fertility Evaluation**

Infertility is defined as the failure to achieve pregnancy after 12 months of regular unprotected intercourse (Agency for Healthcare Research and Quality (AHRQ), 2008; American Society of Reproductive Medicine (ASRM), 2013). Infertility can affect one or both reproductive partners. Some underlying factors are reversible through medical intervention; the major underlying causes of infertility include: ovulatory, tubal, cervical, uterine/endometrial, and male partner factors. There are some genetic factors responsible for male factor infertility, including chromosome abnormalities, Y-chromosome microdeletions, and mild/non-classical cystic fibrosis.

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All men with severe oligozoospermia or azoospermia (sperm count < 5 million/hpf) should be offered genetic counseling, karyotype assessment for chromosomal abnormalities, and Y-chromosome microdeletion testing prior to initiating in vitro fertilization with intracytoplasmic sperm injection (Okun and Sierra 2014). Cystic fibrosis testing is also indicated for males with obstructive azoospermia.

## Professional Society Guidelines

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# Revision History

## Clinical Steering Committee Review:

v2.2017 03/08/2017: Approved

v1.2017 01/25/2017: Approved

## Revisions:

Version	Date	Editor	Description
v3.2017	10/26/2017	Kate Charyk, MS, CGC	Quarterly Review. Added simultaneous screening to indications for which cfDNA is not medically necessary. Added additional background evidence and references for PGS.
v2.2017	09/11/2017	Megan Czarniecki, MS, CGC	Formatted references to NLM style. Moved methodological considerations to appropriate use criteria and background. Updated

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			associated CPT codes. Added disclaimer to PGD testing coverage. Approved by Policy Lead.
v2.2017	06/20/2017	Kate Charyk, MS, CGC	Quarterly review. No criteria changes. Reorganized carrier screening criteria under new header. Updated references. Approved by Policy Lead.
v2.2017	04/19/2017	Kate Charyk, MS, CGC	Quarterly review. Added updated ACOG committee opinions #690 and 691 per 3/8/17 CSC approval. Updated references.
v2.2017	03/08/2017	Kate Charyk, MS, CGC	Expanded criteria of SMA to general population carrier screening.
v1.2017	01/23/2017	Kate Charyk, MS, CGC	Quarterly review. No criteria changes. Added paragraph to background regarding prenatal WES. Updated references. Renumbered to 2017 version.
v1.2016	08/01/2016	Gwen Fraley, MS, CGC	Expanded criteria NIPT to average-risk population. Updated references.
v1.2015	04/19/2015	Gwen Fraley, MS, CGC	Original version

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PROPRIETARY

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