

# Lung Cancer Molecular Markers

## Indications for Ordering

Mutation testing to aid in selection of tyrosine kinase inhibitor (TKI) and/or immune checkpoint inhibitor therapy

## Tests to Consider

### Typical testing strategy

Minimum initial recommendation – lung cancer panel that includes simultaneous ordering for mutations in *ALK*, *EGFR*, and *ROS1* genes

### Primary tests

#### Determine eligibility for TKI therapy (panel tests)

##### [Lung Cancer Panel 2008894](#)

- Screening panel detects
  - *EGFR* mutations
  - *ALK* and *ROS1* fusion proteins

##### [Lung Cancer Panel with \*KRAS\* 2008895](#)

- Screening panel detects
  - *EGFR* and *KRAS* mutations
  - *ALK* and *ROS1* fusion proteins

#### Determine eligibility for TKI therapy (single tests)

##### [ALK \(D5F3\) with Interpretation by Immunohistochemistry 2007324](#)

- Detects *ALK* fusion proteins

##### [ALK \(D5F3\) by Immunohistochemistry with Reflex to ALK Gene Rearrangements by FISH 2011431](#)

- Detects *ALK* fusion proteins and *ALK* gene rearrangements in solid tumors

##### [ALK Gene Rearrangements by FISH, Lung 2006102](#)

- Screening test for all *ALK* fusions
- Use this test if the companion diagnostic test for crizotinib is required
- Does not identify the translocation partner or variant

##### [EGFR Mutation Detection by Pyrosequencing 2002440](#)

##### [KRAS Mutation Detection 0040248](#)

- Predicts response to anti-*EGFR* and MAPK pathway therapies in a variety of malignancies (eg, colorectal and lung cancer)

##### [c-MET by Immunohistochemistry 2008652](#)

- Detects overexpression of c-MET protein

##### [MET Gene Amplification by FISH 2013082](#)

- Aids in prognostication and therapeutic decisions for neoplasms where amplification has been demonstrated
- Screening test for *MET* gene amplification

##### [RET Gene Rearrangements by FISH 2012654](#)

- Detects *RET* gene rearrangements in solid tumors
- Does not identify the translocation partner or variant

##### [ROS1 by FISH 2008418](#)

- Detects *ROS1* gene rearrangements in solid tumors
- Does not identify the translocation partner or variant

##### [ROS1 with Interpretation by Immunohistochemistry with Reflex to FISH if Equivocal or Positive 2008414](#)

- Detects *ROS1* fusion proteins and *ROS1* gene rearrangements

#### Screening for immune checkpoint inhibitor therapy FDA-approved PD-L1 companion tests

##### [PD-L1 22C3 pharmDx by Immunohistochemistry with Interpretation, pembrolizumab \(KEYTRUDA\) 2013284](#)

- Aid in prediction of response to pembrolizumab (KEYTRUDA), as first- or second-line therapy, for patients with non-small cell lung cancer (NSCLC)
- Can be performed in conjunction with or instead of PD-L1 28-8

##### [PD-L1 28-8 pharmDx by Immunohistochemistry with Interpretation, nivolumab \(OPDIVO\) 2013684](#)

- Aids in prediction of response to nivolumab for patients with non-squamous NSCLC or melanoma
- Can be performed in conjunction with or instead of PD-L1 22C3

#### Monitor for EGFR T790M resistance

##### [EGFR T790M Mutation Detection in Circulating Tumor DNA by Digital Droplet PCR 2012868](#)

- Monitor blood plasma or cerebrospinal fluid (CSF) for
  - Development of *EGFR* T790M drug-resistant mutation in patients administered TKI therapy for *EGFR*-mutant NSCLC
  - Response to therapy and disease progression in patients receiving *EGFR* T790M-specific TKIs

#### Related test

##### [Solid Tumor Mutation Panel by Next Generation Sequencing 2007991](#)

- Aids in therapeutic decisions for solid tumor cancers
- Simultaneously evaluates mutations in multiple genes, including *AKT1*, *ALK*, *BRAF*, *EGFR*, *ERBB2*, *ERBB4*, *KRAS*, *NRAS*, and *PIK3CA*
- Does not detect translocations

## Test Methodology

### ALK

- Immunohistochemistry (IHC) using ALK clone D5F3
- Fluorescence in situ hybridization (FISH)

### EGFR – polymerase chain reaction (PCR) and pyrosequencing

- Detects mutations at codons 719 (exon 18), 768 and 790 (exon 20), 858 and 861 (exon 21)
- Detects deletions in exon 19

### EGFR T790M (serum) – digital droplet PCR

### KRAS – PCR and pyrosequencing

- Detects mutations at codons 12, 13 (exon 2), and 61 (exon 3)

### c-MET – IHC

### MET – FISH

### PD-L1 – IHC

### RET – FISH

- Detects all *RET* gene fusions

### ROS1 – IHC (using ROS1 clone D4D6) with FISH reflex if equivocal

## Test Interpretation

### Results

Single gene testing (includes genes in panels) – see table

### Limitations

- Results must be interpreted in the context of clinical findings and morphological and other relevant data
- Results may be compromised if the recommended tissue-fixation procedures have not been followed

## Disease Overview

### Incidence

Lung cancer is the second most common cancer in U.S.

### Treatment issues

- Lung cancer has poor response to traditional chemotherapy agents
  - Dismal 5-year outcome when using these agents
  - Newer targeted agents have better response rates in specific individuals and tumor types
- Tumor response rates to targeted therapy are closely associated with mutation status of the tumor, especially for adenocarcinoma or mixed adenocarcinoma subtypes
- Mutation status
  - Determines TKI therapy eligibility
  - Confers resistance to TKIs (eg, *EGFR* T790M mutation)
    - Monitoring in serum for *EGFR* T790M mutation may detect TKI resistance sooner and alter treatment plans
- PD-L1 expression
  - May predict response to immune checkpoint inhibitor therapy

### References

- Francis G, Stein S. Circulating cell-free tumour DNA in the management of cancer. *Int J Mol Sci.* 2015;16;14122-14142
- NCCN Clinical Practice Guidelines in Oncology, Lung Cancer Screening. National Comprehensive Cancer Network. Fort Washington: Pennsylvania [Accessed: January 25, 2016]

Single Gene Testing			
Gene	Testing method	Test result	
ALK	IHC	Positive – cytoplasmic staining in tumor cells Equivocal – very weak cytoplasmic staining visible only on higher power by microscopy Negative – no cytoplasmic staining in tumor cells	May predict response to TKI therapy
	FISH	Positive – <i>ALK</i> gene rearrangements detected in ≥15% of nuclei • Does not identify translocation partner	May predict response to TKI therapy
EGFR	PCR/pyrosequencing	Positive – mutation detected	May predict response to TKI therapy
	<i>EGFR</i> T790M (serum) Digital droplet PCR	Positive – mutation detected • Expressed as percentage	Predicts resistance to TKI therapy
KRAS	PCR/pyrosequencing	Positive – mutation detected	May predict response to TKI therapy
MET	FISH	Positive – detects gene amplification	<ul style="list-style-type: none"> <li>• May predict response to crizotinib TKI therapy</li> <li>• Associated with acquired resistance to <i>EGFR</i> inhibitors in 5-20% of patients with <i>EGFR</i>-mutated tumors</li> </ul>
RET	FISH	Positive – gene rearrangements detected • Does not identify translocation partner	May predict response to TKI therapy
ROS1	IHC FISH reflex	Positive – uniform membranous staining in tumor cells Equivocal – any degree of cytoplasmic staining or focal/weak membranous staining in tumor cells • Reflexes to FISH for confirmation ○ Does not identify translocation partner	May predict response to TKI therapy