National Imaging Associates, Inc.*	
Clinical guidelines **FRACTIONAL FLOW RESERVE CT**	**Original Date: August 2017**
CPT Code: 0501T, 0502T, 0503T, 0504T	**Last Revised Date: March 2020**
Guideline Number: NIA_CG_062-1	**Implementation Date: January 2021**

GENERAL INFORMATION

It is an expectation that all patients receive care/services from a licensed clinician. All appropriate supporting documentation, including recent pertinent office visit notes, laboratory data, and results of any special testing must be provided. All prior relevant imaging results, and the reason that alternative imaging cannot be performed must be included in the documentation submitted.

INDICATIONS FOR FFR-CT

- Intermediate degrees of stenosis (30 - 70%) on coronary computerized tomographic angiography (CCTA) to guide decision making and help identify those patients who would benefit from revascularization

- Intermediate lesions in the above range and coronary calcification has made percentage stenosis interpretation difficult, thus could support approval of FFR-CT, in conjunction with the above criteria (Norgaard, 2015).

FFR-CT – ADDITIONAL INFORMATION: (Douglas, 2016; Pontone, 2015)

None of the following clinical scenarios below apply, since FFR-CT either:

- Has not been adequately validated due to inapplicability of computational dynamics; **OR**
- Due to problematic artifacts, and/or clinical circumstances.
  - When patients have artifacts (heavy calcium) or body habitus (BMI > 35) that could interfere with the examination, the suitability for FFR-CT is at the discretion of the vendor who provides the FFR-CT service
  - Known ischemic coronary artery disease that has not been revascularized and there has been no change in patient status or in the CCTA images
- Recent myocardial infarction within 30 days (Gaur, 2017)
- Prior coronary artery bypass graft surgery
- Complex congenital heart disease or ventricular septal defect (VSD) with pulmonary-to-systemic flow ratio > 1.4

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- Metallic stents ≤ 3.0 mm in diameter in the coronary system
- Coronary lesions with a vessel diameter < 1.8 mm
- Cardiac Implanted Electrical Devices
- Prosthetic Heart Valves
- Severe wall motion abnormality on CCTA results
- Severe myocardial hypertrophy
- High risk indicators on stress test
- Coronary angiography within the past 90 days
- Marginal quality of the submitted imaging data, due to motion, blooming, misalignment, arrhythmia, etc.

BACKGROUND
(Hulten, 2017; Maroules, 2017)

Fractional flow reserve computed tomography (FFR-CT) is a relatively new technology that estimates the effect of coronary arterial narrowing on blood flow, based upon the images acquired in a coronary computed tomography angiography study. Its role is to provide information that can more appropriately select patients requiring invasive coronary angiography.

OVERVIEW
The Development of FFR-CT as a Technology:

History of FFR: Fractional Flow Reserve (FFR) is the ratio of baseline coronary flow to coronary flow during maximal hyperemia. Its use in the cardiac catheterization laboratory has successfully demonstrated utility in the quantitation of intracoronary flow dynamics secondary to lesional and microvasculature conditions. This technology has proven helpful in evaluating individual patients, with respect to prognostication of coronary artery disease and decisions regarding the appropriateness of coronary revascularization (De Bruyne, 2014; Pijls, 2007; Tonino, 2009; van Nunen, 2015; Xaplanteris, 2018).

Adaptation to CCTA: CCTA has shown utility in the evaluation of patients with stable chest pain, typically intermediate pretest probability, warranting non-invasive evaluation (Douglas, 2015b; Newby, 2015; Oberweis, 2017; Williams, 2016), as well as in low risk emergency department scenarios (Hulten, 2013). Fractional flow reserve using CCTA seeks to provide an estimation of FFR by non-invasive methodology. Following assessment of quality CCTA images, in the appropriate subsets of patients with coronary stenoses, the technology makes mathematical assumptions to simulate maximal hyperemia and calculates an estimation of FFR (fractional flow reserve) for those coronary vessels with lesions, based upon the principles of fluid mechanics inherent to the Navier-Stokes Theorem (Taylor, 2013).

FFR-CT Results: Quantitative estimation of coronary lesional hemodynamic severity using FFR-CT might enable deferral of invasive coronary arteriography when values are above 0.80, since such lesions would not warrant revascularization.

FFR-CT measurements appear reproducible (Gaur, 2014), with initial data demonstrating a strong correlation to invasive FFR, resulting in a high diagnostic performance (Driessen, 2019). Invasive FFR has excellent reproducibility (Johnson, 2015) and a demonstrated track record of favorable outcomes when used in the selection of patients and vessels requiring PCI (De Bruyne, 2014; Tonino, 2009; Van Nunen, 2015; Xaplanteris, 2018). Evidence suggests that FFR-CT might be a better predictor of revascularization or adverse events than severe stenosis alone on CCTA (Lu, 2016) and that a negative FFR-CT in the evaluation of chest pain results in lower revascularization rates and lower cardiovascular death and MI at 1 year follow-up (Patel, 2020). The FFR-CT data to date, however, provide no evidence showing that revascularization based upon FFR-CT improves clinical outcomes over invasive angiographic assessment. As a consequence of the above considerations, current revascularization guidelines do not advocate FFR-CT as a surrogate for invasive FFR, although, those guidelines refer to FFR-CT as an "emerging technology" (Patel, 2017).

Abbreviations

BMI	Body Mass Index
CCTA	Coronary Computerized Tomographic Angiography
FFR	Fractional Flow Reserve
FFR-CT	Fractional Flow Reserve derived noninvasively from CCTA
ICA	Invasive Coronary Arteriography
NPV	Negative Predictive Value

POLICY HISTORY:
Review Date: August 2019
Review Summary:

- Added the following clarification: Intermediate degrees of stenosis (30 - 70%) on coronary computerized tomographic angiography (CCTA) to guide decision making and help identify those patients who would benefit from revascularization
- Clarified metallic stents in the coronary system to be ≤ 3.0 mm in diameter as potentially inapplicable

- Removed acute coronary syndrome and emergent scenarios
- Removed section on pre-test probability and selection of patients for CCTA

Review Date: March 2020
Review Summary:

- Added general information section as Introduction which outlines requirements for documentation of pertinent office notes by a licensed clinician, and inclusion of laboratory testing and relevant imaging results for case review
- Added additional information to the FFR-CT Results section
- Updated and added new references

REFERENCES

Collet C, Miyazaki Y, Ryan N, et al. Fractional flow reserve derived from computed tomographic angiography in patients with multivessel CAD. *J Am Coll Cardiol*. 2018; 71(24:535. Available at: http://www.onlinejacc.org/content/early/2018/04/19/j.jacc.2018.02.053?_ga=2.67580952.885425748.1527125307-379059663.1523731136 Retrieved May 24, 2018

De Bruyne B, Fearon WF, Pijls NH, et al. Fractional flow reserve–guided PCI for stable coronary artery disease. *New Eng J Med*. 2014; 371(13):1208–17.

Detrano R, Yiannikas J, Salcedo EE, et al. Bayesian probability analysis: a prospective demonstration of its clinical utility in diagnosing coronary disease. *Circulation.* 1984; 69(3):541-7.

Dewey M, Rief M, Martus P, et al. Evaluation of computed tomography in patients with atypical angina or chest pain clinically referred for invasive coronary angiography: Randomised controlled trial. *Br Med J*. 2016; 355.

Douglas PS, De Bruyne B, Pontone G, et al. 1-Year outcomes of FFRCT-guided care in patients with suspected coronary disease: The PLATFORM Study. *J Am Coll Cardiol*. 2016; 68(5):435-45. Available at: https://www.sciencedirect.com/science/article/pii/S0735109716333952?via%3Dihub.

Douglas PS, Pontone G, Hlatky MA, et al. Clinical outcomes of fractional flow reserve by computed tomographic angiography-guided diagnostic strategies vs. usual care in patients with suspected coronary artery disease: The prospective longitudinal trial of FFR (CT): Outcome and resource impacts study. *Eur Heart J.* 2015a; 36(47):3359-67.

Douglas PS, Hoffman U, Patel MR, et al. Outcomes of anatomical versus functional testing for coronary artery disease. *New Eng J Med.* 2015b; 372:1291-1300.

Driessen RS, Danad I, Stuijfzand WJ, et al. Comparison of coronary computed tomography angiography, fractional flow reserve, and perfusion imaging for ischemia diagnosis. *J Am Coll Cardiol*. 2019; 73:161–173.

Fihn SD, Gardin JM, Abrams J, et al. 2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS Guideline for the diagnosis and management of patients with stable ischemic heart disease: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, and the American College of Physicians, American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *Circulation.* 2012; 126(25):e354-471.

Gaur S, Bezerra HG, Lassen JF, et al. Fractional flow reserve derived from coronary CT angiography: variation of repeated analyses. *J Cardiovasc Comput Tomogr*. 2014; 8(4):307-314.

Gaur S, Taylor CA, Jensen JM, et al. FFR Derived From coronary CT angiography in nonculprit lesions of patients with recent ST-segment elevation myocardial infarction. *J Am Coll Cardiol*. 2017; 10(4): 424-433**.**

Graham IM. Diagnosing coronary artery disease—the Diamond and Forrester model revisited. *Eur Heart J.* 2011; 32(11):1311-2.

Groves P, Denison F, Bennett S, et al. HeartFlow FFRCT for estimating fractional flow reserve from coronary CT angiography. National Institute for Health and Care Excellence. United Kingdom, Feb, 2017. Available at: https://www.nice.org.uk/guidance/mtg32. Retrieved May 23, 2018.

Hlatky MA, De Bruyne B, Pontone G, et al. Quality-of-life and economic outcomes of assessing fractional flow reserve with computed tomography angiography: PLATFORM. *J Am Coll Cardiol.* 2015; 66(21):2315-23.

Hulten EA. Does FFR-CT have proven utility as a gatekeeper prior to invasive angiography? *J Nucl Cardiol*. 2017; 24:1619–25.

Hulten E, Blankstein R, Di Carli MF. The value of noninvasive FFRCT in our current approach to the evaluation of coronary artery stenosis. *Curr Opin Cardiol.* 2016; 31(6): 970–976.

Hulten E, Di Carli MF. FFRCT: solid PLATFORM or thin ice? *J Am Coll Cardiol.* 2015; 66(21):2324-2328.

Hulten E, Pickett C, Bittencourt MS, et al. Outcomes after coronary computed tomography angiography in the emergency department: Systematic review and meta-analysis of randomized, controlled Trials. *J Am Coll Cardiol.* 2013; 61(8):880-892. Available at: http://dx.doi.org/10.1016/j.jacc.2012.11.061.

Johnson NP, Johnson DT, Kirkeeide RL, et al. Repeatability of fractional flow reserve despite variations in systemic and coronary hemodynamics. *J Am Coll Cardiol Cardiovasc Interv.* 2015; 8(8):1018-1027. Available at: https://www.sciencedirect.com/science/article/pii/S1936879815006998?via%3Dihub.

Koo B-K, Erglis A, Doh J-H, et al. Diagnosis of ischemia-causing coronary stenoses by noninvasive fractional flow reserve computed from coronary computed tomographic angiograms results from the prospective multicenter DISCOVER-FLOW (Diagnosis of ischemia-causing stenoses obtained via noninvasive fractional flow reserve) study. *J Am Coll Cardiol.* 2011; 58(19):1989–97.

Labounty TM, Nallamothu BK. FFR (CT): A new technology in search of a clinical application. *Eur Heart J.* 2015; 36(47):3368-9. Available at:https://academic.oup.com/eurheartj/article/36/47/3368/2398364.

Labounty TM. FFR-CT in patients with multivessel CAD. *Cardiosource, Am Coll Cardiol,* Washington, DC, May 22, 2018. Available at: http://www.acc.org/latest-in-cardiology/journal-scans/2018/05/22/09/02/fractional-flow-reserve-derived-from-ct?utm_campaign=clinical_topics&utm_source=clinical_topics&utm_medium=email_digest Retrieved May 24, 2018.

Linker DT. Decision-support tool to calculate pre- and post-test probabilities of coronary artery disease with cardiac functional tests. University of Washington, WA. June 19, 2000; Available at: http://faculty.washington.edu/dtlinker/CAD.html Retrieved May 22, 2018

Lu MT, Ferencik M, Roberts RS, et al, Noninvasive FFR derived from coronary CT angiography: Management and outcomes in the PROMISE Trial. *J Am Coll Cardiol Cardiovasc Imaging.* 2017; 10(11):1350-1358. https://www.sciencedirect.com/science/article/pii/S1936878X17302620?via%3Dihub.

Maroules C, Cury RC. CT perfusion and FFRCT are ready for clinical use. *Cardiosource - Am Coll Cardiol.* Washington, DC, Feb 6, 2017/ Available at: http://www.acc.org/latest-in-cardiology/articles/2017/02/06/11/11/ct-perfusion-and-ffrct-are-ready-for-clinical-use Retrieved May 22, 2018.

Min JK, Leipsic J, Pencina MJ, et al. Diagnostic accuracy of fractional flow reserve from anatomic CT angiography. *JAMA.* 2012; 308(12):1237–45.

Min JK. Look backwards but live forwards. *J Am Coll Cardiol Cardiovasc Imaging.* 2017; 10(5):551-553.

Nakanishi R, Budoff MJ. Noninvasive FFR derived from coronary CT angiography in the management of coronary artery disease: Technology and clinical update. *Vasc Health Risk Manag*. 2016; 12:269-78.

Newby D, Williams M, Hunter A, SCOT-Heart Investigators, et al. CT coronary angiography in patients with suspected angina due to coronary heart disease (SCOT-HEART): An open-label, parallel-group, multicentre trial. *Lancet.* 2015; 385(9985):2383–2391.

Norgaard BL, Leipsic J, Gaur S, et al. Diagnostic performance of noninvasive fractional flow reserve derived from coronary computed tomography angiography in suspected coronary artery disease: The NXT trial (Analysis of coronary blood flow using CT angiography: Next steps). *J Am Coll Cardiol.* 2014; 63(12):1145–55.

Nørgaard BL, Gaur S, Leipsic J, et al. Influence of coronary calcification on the diagnostic performance of CT angiography derived FFR in coronary artery disease: A substudy of the NXT Trial. *J Am Coll Cardiol Cardiovasc Imaging.* Sep 2015; 8(9):1045-1055. Available at: http://ac.els-cdn.com/S1936878X15004209/1-s2.0-S1936878X15004209-

main.pdf?_tid=1f36befc-8e9f-11e7-96c4-00000aab0f02&acdnat=1504220153_7781c1008bf3f875aeef2f85b0c5e65d.

Norgaard BL, Hjort J, Gaur S, et al. Clinical use of coronary CTA–derived FFR for decision-making in stable CAD. *J Am Coll Cardiol Cardiovascular Imaging*. 2017; 10(5)5451-550. Available at: https://www.sciencedirect.com/science/article/pii/S1936878X16300407?via%3Dihub.

Oberweis BS, Taylor AJ. The PROMISE trial: The CTA perspective. *Cardiosource, Am Coll Cardiol.* Washington, DC, July 28, 2018. Available at: http://www.acc.org/latest-in-cardiology/articles/2015/07/27/10/58/the-promise-trial-the-cta-perspective Retrieved May 23, 2018.

Packard S, Karlsberg RP. Integrating FFRCT into routine clinical practice: A solid PLATFORM or slippery slope? *J Am Coll Cardiol.* 2016; 68(5):446-9.

Patel MR, Calhoon JH, Dehmer GJ, et al. ACC/AATS/AHA/ASE/ASNC/SCAI/SCCT/STS 2017 Appropriate use criteria for coronary revascularization in patients with stable ischemic heart disease. *J Am Coll Cardiol.* 2017; 69(17):2212-2241.

Patel MP, Nørgaard BL, Fairbaim TA, et al. 1-Year Impact on Medical Practice and Clinical Outcomes of FFRCT. *J Am Coll Cardiol Img*. 2020 Jan 13; 1(1):97-105.

Pijls NH, van Schaardenburgh P, Manoharan G, et al. Percutaneous coronary intervention of functionally nonsignificant stenosis: 5-year follow-up of the DEFER Study. *J Am Coll Cardiol.* 2007; 49(21):2105–11.

Pontone G, Patel MR, Hlatky MA, et al. Rationale and design of the PLATFORM (Prospective LongitudinAl Trial of FFRct: Outcome and Resource IMpacts) study: design of the PLATFORM study. *Am Heart J.* 2015; 170: 438–46. Available at: https://www.ahjonline.com/article/S0002-8703(15)00369-5/fulltext.

Taylor CA, Fonte TA, Min JK. Computational fluid dynamics applied to cardiac computed tomography for noninvasive quantification of fractional flow reserve: Scientific Basis. *J Am Coll Cardiol.* 2013; 61:2233–41.

Tonino PA, De Bruyne B, Pijls NH, et al. Fractional flow reserve versus angiography for guiding percutaneous coronary intervention (FAME). *New Eng J Med*. 2009; 360(3):213–24.

Van Nunen LX, Zimmermann FM, Tonino PA, et al. Fractional flow reserve versus angiography for guidance of PCI in patients with multivessel coronary artery disease (FAME): 5-year follow-up of a randomised controlled trial. *Lancet.* 2015; 386(10006):1853-1860.

Williams MC, Hunter A, Shah ASV, et al. Use of coronary computed tomographic angiography to guide management of patients with coronary disease. *J Am Coll Cardiol.* 2016; 67(15):1759-1768.

Xaplanteris P, Fournier S, Pijls HJ, et al. Five-year outcomes with PCI guided by fractional flow reserve (FAME-2). *NEJM.* 2018; May 22, in press. https://www.nejm.org/doi/pdf/10.1056/NEJMoa1803538 Retrieved May 23, 2018.

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