

## Imbio Lung Texture Analysis™

(with CALIPER technology exclusively licensed from Mayo Clinic)

### Bibliography of Peer-Reviewed Scientific Literature

**Regulatory Clearance Notice:** Lung Texture Analysis (LTA) is CE Mark certified and Health Canada Approved. LTA is not FDA cleared and is for research use only in the U.S. and other regions without regulatory clearance for clinical use.

**Indications for Use:** The Imbio CT LTA Software uses CT density values of pulmonary tissue to provide quantitation and visualization in support of diagnosis. The Imbio CT LTA Software performs three-dimensional segmentation and classifies the lung voxels into typical radiological categories. Automated reports and color overlays of the analysis are provided to support diagnosis when abnormal lung parenchymal densities are present.

Below is a representative sampling of published scientific and technical peer-reviewed articles that relate to Lung Texture Analysis, and its core embedded technology - known as "CALIPER" - used for classification of the pulmonary tissue. This bibliography is being provided by way of illustration of the scientific discourse on the subject.

### General Technology Background

#### **Quantitative computed tomography imaging of interstitial lung diseases.**

Bartholmai BJ, Raghunath S, Karwoski RA, Moua T, Rajagopalan S, Maldonado F, Decker PA, Robb RA. J Thorac Imaging 2013;28:298–307. PMID: 23966094 PMCID: 3850512 DOI: 10.1097/RTI.0b013e3182a21969

(Additional disclosure: B. Bartholmai is a named inventor of CALIPER technology, which is licensed to Imbio, Inc.)

#### **High resolution multidetector CT-aided tissue analysis and quantification of lung fibrosis.**

Zavaletta VA, Bartholmai BJ, Robb RA. Acad Radiol. 2007 Jul;14(7)772-87. PMID: 17574128 PMCID: 2701291 DOI: 10.1016/j.acra.2007.03.009

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### Potential Prognostic Value: Correlations to Lung Function & Survival

#### **Volume-related structures predict UIP pathology in those with a non-IPF pattern on CT.**

Chung JH, Adegunsoye A, Oldham JM, Vij R, Husain A, Montner SM, Karwoski RA, Bartholmai BJ, Strek ME. Eur Radiol. 2021 Apr 13. DOI: 10.1007/s00330-021-07861-6 Online ahead of print.

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**Quantitative and semi-quantitative computed tomography analysis of interstitial lung disease associated with systemic sclerosis: A longitudinal evaluation of pulmonary parenchyma and vessels.** Occhipinti M, Bosello S, Sisti LG, et al. PloS One. 2019 Mar 12;14(3):e0213444. PMID: 30861018 DOI: 10.1271/journal.pone.0213444

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**Predicting outcomes in rheumatoid arthritis related interstitial lung disease.** Jacob J, Hirani N, van Moorsel CHM, Rajagopalan S, Murchison JT, van Es HW, Bartholmai BJ, van Beek FT, Struik MHL, Stewart GA, Kokosi M, Egashira R, Brun AL, Cross G, Barnett J, Devaraj A, Margaritopoulos G, Karwoski R, Renzoni E, Maher TM, Wells AU. Eur Respir J. 2019 Jan 3;53(1):1800869. PMID: 30487199 PMCID: PMC6319797 DOI: 10.1183/13993003.00869-2018

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**Quantitative analysis of lung sounds for monitoring idiopathic pulmonary fibrosis: a prospective pilot study.** Sgalla G, Larici AR, Sverzellati N, Bartholmai B, Walsh SLF, Nikolic D, Barney A, Fletcher S, Jones M, Davies DD, Richeldi L. Eur Respir J. 2019 Mar 7;53(3):1802093. PMID: 30578384 DOI: 10.1183/13993003.02093-2018

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**Longitudinal prediction of outcome in idiopathic pulmonary fibrosis using automated CT analysis.** Jacob J, Bartholmai BJ, van Moorsel CHM, Rajagopalan S, Devaraj A, van Es HW, Moua T, van Beek FT, Clay R, Veltkamp M, Kokosi M, de Laetis A, Judge EP, Jacob TM, Peikert T, Karwoski R, Maldonado F, Renzoni E, Maher TM, Altmann A, Wells AU. Eur Respir J. 2019 Sep 30;54(3):1802341. PMID: 31196945 PMCID: PMC6860992 DOI: 10.1183/13993003.02341-2018

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**Predicting Outcomes in Idiopathic Pulmonary Fibrosis Using Automated Computed Tomographic Analysis.** Jacob J, Bartholmai BJ, Rajagopalan S, Walsh SL, Wells AU, et al. Am J Respir Crit Care Med 2018 Sep 15;198(6):767-76. PMID: 29684284 DOI: 10.1164/rccm.201711-2174OC

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**Short-term Automated Quantification of Radiologic Changes in the Characterization of Idiopathic Pulmonary Fibrosis Versus Nonspecific Interstitial Pneumonia and Prediction of Long-term Survival.** De Giacomo F, Raghunath S, Karwoski R, Bartholmai BJ, Moua T. J Thorac Imaging. 2018 Mar;33(2):124-131. PMID: 29219887 DOI: 10.1097/RTI.0000000000000317

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**Evaluation of visual and computer-based CT analysis for the identification of functional patterns of obstruction and restriction in hypersensitivity pneumonitis.**

Jacob J, Bartholmai BJ, Brun AL, Egashira R, Rajagopalan S, Karwoski R, Kouranos V, Kokosi M, Hansell DM, Wells AU. Respirology. 2017 Nov;22(8):1585-1591. PMID: 28699237 DOI: 10.1111/resp.13122

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**Novel Assessment of Interstitial Lung Disease Using the "Computer-Aided Lung Informatics for Pathology Evaluation and Rating" (CALIPER) Software System in**

**Idiopathic Inflammatory Myopathies.** Ungprasert P, Wilton KM, Ernste FC, Kalra S, Crowson CS, Rajagopalan S, Bartholmai BJ. Lung. 2017 Oct;195(5):545-552. PMID: 28688028 DOI: 10.1007/s00408-017-0035-0

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**Unclassifiable-interstitial lung disease: Outcome prediction using CT and functional indices.** Jacob J, Bartholmai BJ, Rajagopalan S, et al. Respir Med. 2017 Sept;130:43-51.

PMID: 29206632 DOI: 10.1016/j.rmed.2017.07.007

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**Serial automated quantitative CT analysis in idiopathic pulmonary fibrosis: functional correlations and comparison with changes in visual CT scores.**

Jacob J, Bartholmai BJ, Rajagopalan S, Kokosi M, Egashira R, Brun AL, Nair A, Walsh SLF, Karwoski R, Wells AU. Eur Radiol. 2017 Sep 29 Epub 2017 Sept 29 PMID: 28963678 DOI: 10.1007/s00330-017-5053-z

*(Additional disclosure: B. Bartholmai is a named inventor of CALIPER technology, which is licensed to Imbio, Inc.)*

**Automated computer-based CT stratification as a predictor of outcome in hypersensitivity pneumonitis.** Jacob J, Bartholmai BJ, Rajagopalan S, Karwoski R, Mak SM, Mok W, Della Casa G, Sugino K, Walsh SLF, Wells AU, Hansell DM. Eur Radiol. 2017 Sep; 27 (9):3635-3646 Epub 2017 Jan 27 PMID: 28130610 DOI: 10.1007/s00330-016-4697-4

*(Additional disclosure: B. Bartholmai is a named inventor of CALIPER technology, which is licensed to Imbio, Inc.)*

**Functional and prognostic effects when emphysema complicates idiopathic pulmonary fibrosis.** Jacob J, Bartholmai BJ, Rajagopalan S, Kokosi M, Maher TM, Nair A, Karwoski R, Renzoni E, Walsh SLF, Hansell DM, Wells AU. Eur Respir J. 2017 Jul; 50 (1) Epub 2017 July 05 PMID: 28679612 DOI: 10.1183/13993003.00379-2017

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**Chronic hypersensitivity pneumonitis: identification of key prognostic determinants using automated CT analysis.** Jacob J, Bartholmai BJ, Egashira R, Brun AL, Rajagopalan S, Karwoski R, Kokosi M, Hansell DM, Wells AU. BMC Pulm Med. 2017 May 04; 17: (1)81. PMID: 28472939 PMCID: 5418678 DOI: 10.1186/s12890-017-0418-2

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**Mortality prediction in idiopathic pulmonary fibrosis: evaluation of computer-based CT analysis with conventional severity measures.** Jacob J, Bartholmai BJ, Rajagopalan S, Kokosi M, Nair A, Karwoski R, Walsh SLF, Wells AU, Hansell DM. European Respiratory Journal. 2017 Jan; 49: (1)1601011

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**Evaluation of computer-based computer tomography stratification against outcome models in connective tissue disease-related interstitial lung disease: a patient outcome study.**

Jacob J, Bartholmai BJ, Rajagopalan S, Brun AL, Egashira R, Karwoski R, Kokosi M, Wells AU, Hansell DM.

BMC Med. 2016 Nov 23; 14: (1)190. PMID: 27876024 PMCID: 5120564 DOI: 10.1186/s12916-016-0739-7

**Quantitative stratification of diffuse parenchymal lung diseases.** Raghunath S, Rajagopalan S, Karwoski RA, Maldonado F, Peikert T, Moua T, Ryu JH, Bartholmai BJ, Robb RA. PloS one 2014 Mar 29;9(3):e93229. PMID: 24676019 PMCID: PMC3968138 DOI: 10.1371/journal.pone.0093229  
(Additional disclosure: B. Bartholmai is a named inventor of CALIPER technology, which is licensed to Imbio, Inc.)

**Automated quantification of radiological patterns predicts survival in idiopathic pulmonary fibrosis.** Maldonado F, Moua T, Rajagopalan S, Karwoski RA, Raghunath S, Decker PA, Hartman TE, Bartholmai BJ, Robb RA, Ryu JH. Eur Respir J. 2014 Jan; 43: (1)204-12. PMID: 23563264 DOI: 10.1183/09031936.00071812  
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## In Quantitative CT Review/Editorial Articles

**Computer-Aided quantitative analysis in interstitial lung diseases: A pictorial review using CALIPER.** Jankharia B, Angirish B. Lung India. Mar-Apr 2021;38(2):161-7. PMID: 22687011 DOI: 10.4103/lungindia.lungindia\_244\_20

**Automated CT Analysis of Major Forms of Interstitial Lung Disease.** Crews MS, Bartholmai BJ, Adegunsoye A, Oldham JM, Montner SM, Karwoski RA, Husain AN, Vij R, Noth I, Streck ME, Chung JH. J Clin Med. 2020 Nov 23;9(11):3776. PMID: 33238466 DOI: 10.3390/jcm9113776  
(Additional disclosure: B. Bartholmai is a named inventor of CALIPER technology, which is licensed to Imbio, Inc.)

**Computed Tomographic Biomarkers in Idiopathic Pulmonary Fibrosis. The Future of Quantitative Analysis.** Wu X, Kim GH, Salisbury ML, Barber D, Bartholmai BJ, Brown KK, Conoscenti CS, De Backer J, Flaherty KR, Gruden JF, Hoffman EA, Humphries SM, Jacob J, Maher TM, Raghu G, Richeldi L, Ross BD, Schlenker-Herceg R, Sverzellati N, Wells AU, Martinez FJ, Lynch DA, Goldin J, Walsh SLF. Computed Tomographic Biomarkers in Idiopathic Pulmonary Fibrosis. The Future of Quantitative Analysis. Am J Respir Crit Care Med. 2019 Jan 1;199(1):12-21 PMID: 29986154. DOI: 10.1164/rccm.201803-0444PP.  
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**Experimental and quantitative imaging techniques in interstitial lung disease.** Weatherley ND, Eaden JA, Stewart NJ, Bartholmai BJ, Swift AJ, Bianchi SM, Wild JM. Thorax. 2019 Jun;74(6):611-619. doi: 10.1136/thoraxjnl-2018-211779. PMID: 30886067 PMCID: PMC6585263.  
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