BIOGRAPHICAL SKETCH

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NAME: Diego Jaramillo, M.D., M.P.H.

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POSITION TITLE: Professor of Radiology, Columbia University Medical Center

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Pontificia Universidad Javeriana, Colombia	MD	1981	Medicine
University of Miami, Miami		1982-1983	Medicine Internship
University of Texas, Houston		1983-1987	Radiology
Harvard University, Boston		1987-1989	Pediatric Radiology
Harvard School of Public Health, Boston	MPH	2002	Quantitative Methods

A. Personal Statement

I am a pediatric radiologist specialized in imaging musculoskeletal disorders in children. I obtained a M.P.H. concentrating on quantitative methods for clinical research. My research has focused on the use of novel imaging technologies, mainly MRI-based, to develop basic and translational approaches to the study of growth disorders. My proposal "Early Diagnosis of Growth Disorders using MRI" was funded by R-29 (1995-1999) and R01 (2001-2006) grants. We clarified the MRI characteristics of the normal and injured physis by correlating imaging with histology in animal models of direct and indirect insults to the physis. We also pioneered the use of diffusion and perfusion MR imaging for evaluation of epiphyseal ischemia and its secondary physeal damage. The initial use of DTI in the physeal region was published by our group in 2003 on the article #1 listed below. Subsequently, we showed that diffusion tensor imaging demonstrates the columnar architecture of the physeal/metaphyseal region, that tract volumes and lengths are higher in children during the period of greatest growth and that DTI metrics decrease in patients with growth failure. I have published more than 130 original peer reviewed publications and more than 80 reviews and chapters. The following publications are directly related to the current proposal. The last five projects (#2-6), use the technology specifically described in this proposal, which we have now applied in more than two hundred children.

1. **Jaramillo, D.,** Connolly, S.A., Vajapeyam, S., Robertson, R.L., Dunning, P.S., Mulkern, R.V., Hayward, A., Maier, S.E., Shapiro, F.: Normal and ischemic epiphysis of the femur: diffusion MR imaging study in piglets. Radiology 2003; 227:825-832.
2. Jaimes C, Berman JI, Delgado J, Ho-Fung V, **Jaramillo D**. Diffusion-tensor imaging of the growing ends of long bones: pilot demonstration of columnar structure in the physes and metaphyses of the knee. Radiology. 2014; 273(2):491-501.
3. Bedoya MA, Delgado J, Berman JI, Chauvin NA, Zurakowski D, Ramirez-Grueso R, Ntoulia A, **Jaramillo D**. Diffusion-Tensor Imaging of the Physes: A Possible Biomarker for Skeletal Growth-Experience with 151 Children. Radiology. 2017 Jul;284(1):210-218
4. Delgado J, **Jaramillo D**, Chauvin NA, Guo M, Stratton MS, Sweeney HE, Barrera CA, Mostoufi-Moab S. Evaluating growth failure with diffusion tensor imaging in pediatric survivors of high-risk neuroblastoma treated with high-dose cis-retinoic acid. Pediatr Radiol 2019; 49:1056-1065

5. Barrera CA, Bedoya MA, Delgado JA, Berman JI, Chauvin NA, Edgar JC, **Jaramillo D.** Correlation between diffusion tensor imaging parameters of the distal femoral physis and adjacent metaphysis, and subsequent adolescent growth. Pediatr Radiol 2019; 49:1191-1200
6. Duong PT, Mostoufi-Moab S, Garcia del Olmo JM, Jaimes J, Delgado J, **Jaramillo D.** Imaging Biomarkers of the Physis: Cartilage Volume on MR Imaging vs. Tract Volume and Length on Diffusion Tensor Imaging. Submitted for publication, Pediatr Radiol

B. Positions and Honors

Professional Positions:

1989 to 1991	Assistant in Radiology, Massachusetts General Hospital, Boston, Massachusetts
1990 to 1992	Instructor in Radiology, Harvard Medical School, Boston, Massachusetts
1991 to 2000	Radiologist, Children's Hospital, Boston, Massachusetts
1992 to 1997	Assistant Professor of Radiology, Harvard Medical School, Boston, Massachusetts
1997 to 2004	Associate Professor of Radiology, Harvard Medical School, Boston, Massachusetts
1999 to 2000	Chief, Division of Pediatric Research, Children's Hospital, Boston Massachusetts
2000 to 2004	Chief, Division of Pediatric Radiology, Massachusetts General Hospital, Boston, Massachusetts
2004-15	Professor of Radiology, Univ. of Pennsylvania School of Medicine, Philadelphia, Pennsylvania
2004-15	Radiologist-in-Chief and Van Alen Chair, Children's Hospital of Philadelphia, Philadelphia, PA
2015-16	Professor and Associate Chair of Radiology, Stanford University School of Medicine
2016-	Adjunct Professor of Radiology, Stanford University School of Medicine
2016	President, Society for Pediatric Radiology
2017	Chair, Board of Directors, Society for Pediatric Radiology
2018-	Professor of Radiology, Columbia University Medical Center

Editorial Boards

2008-15	Deputy Editor, Pediatric Imaging, Journal of Magnetic Resonance Imaging
2008	Editorial Board, Colombian Journal of Radiology (Revista Colombiana de Radiologia)
2010-16	Editorial Board, Radiology, Associate Editor for Pediatric Imaging
2011-	Editorial Board, Pediatric Radiology

Membership in Review Panels

Diagnostic Study Section Member Special Emphasis Panel/Initial Review Group 2004/10 ZRG June 10, 2004
Medical Bone Imaging Special Emphasis Panel. ZRG1 SBIB February 7, 2005
Biomedical Imaging and Imaging Technology Special Emphasis Panel 2005/10 ZGRB1 June 7, 2005
Center for Scientific Review Special Emphasis Panel; ZRG1 SBIB-S (90) February 8, 2006
Center for Scientific Review Special Emphasis Panel; ZRG1 SBIB-S (02) February 8, 2006;

Honors

1993	Magna Cum Laude Award, Society for Magnetic Resonance Imaging
1993-95	Scholar Award, Radiological Society of North America
1995	John Caffey Award for best research paper, Society for Pediatric Radiology
1991,2001	Lawrence L. Robbins & Jack Wittenberg Teaching Awards, Massachusetts Gen. Hospital
2004	Medical Student Teaching Award in Radiology, Harvard Medical School
2010	"A una obra" – Highest award given to a radiologist by the Colombian Radiological Association
2014	Pioneer Award of the Society for Pediatric Radiology

C. Contribution to Science

Complete List of Published Works:
http://www.ncbi.nlm.nih.gov/sites/myncbi/1Pes8HFK20A5j/bibliography/48090468/public/?sort=date&direction=ascending

1. MR Imaging of Growth Disorders
1A. Injury to the Growing Skeleton

The physis is a structure that is easily identifiable by MR imaging (MRI), and we defined that disorders of growth become apparent on MRI earlier than they are radiographically or clinically. I was the principal investigator in the research. We found that MRI can identify direct injuries to the physis, either due to trauma or infection, and help predict whether there is a risk of subsequent focal physeal closure, and therefore shortening and deformity. MRI can also show indirect injuries to the physis, either from ischemia or other insults such as radiation. These insults lead to physeal disorganization and to altered endochondral ossification with cartilage remaining in the metaphysis. Rickets also results in cartilage in the metaphysis and is well defined by MRI. This work has led to imaging protocols of the physis and physeal disorderswhich have now become standard.

a. **Jaramillo, D.,** Shapiro, F., Hoffer, F.A., Winalski, C.S., Koskinen, M.F., Frasso, R., Johnson, A.: Posttraumatic growth-plate abnormalities: MR imaging of bony-bridge formation in rabbits. Radiology 1990; 175:767-773.
b. **Jaramillo, D.,** Hoffer, F.A., Shapiro, F., Rand, F.: MR imaging of fractures of the growth plate. AJR American Journal of Roentgenology 1990; 155:1261-1265.
c. **Jaramillo, D.,** Laor, T., Zaleske, D.J.: Indirect trauma to the growth plate: results of MR imaging after epiphyseal and metaphyseal injury in rabbits. Radiology 1993; 187:171-178.
d. Ecklund, K., **Jaramillo, D**.: Patterns of premature physeal arrest: MR imaging of 111 children. AJR American Journal of Roentgenology 2002; 178:967-972.

1B. Imaging of Normal and Abnormal Vascularity of the Growing Skeleton

Given that ischemia is a common source of growth disorders, it is important to evaluate the vascularity of the epiphysis, the area adjacent to the joint that supplies the vascularity to the physis. The epiphysis is initially cartilaginous and then becomes progressively bony as the epiphyseal ossification center grows. I was the principal investigator in the research. We identified that perfusion of the cartilaginous epiphysis can be detected with gadolinium enhanced MRI. Gadolinium (Gd) leaks from the vessels into canals that supply the epiphyseal cartilage, and finally diffuses into the cartilage. We demonstrated that in a piglet model of hip ischemia due to hyperabduction cartilaginous ischemia is detectable after Gd administration, and that similar changes can be seen in children treated with abduction for hip dysplasia. Using dynamic MRI, we also showed that the metaphyseal spongiosa and the cambium layer of the periosteum are the most vascularized regions in the growing skeleton. These principles are now used routinely in imaging of epiphyseal disorders, particularly ischemia.

a. **Jaramillo, D.,** Villegas-Medina, O.L., Doty, D.K., Dwek, J.R., Ransil, B.J., Mulkern, R.V., Shapiro, F: Gadolinium-enhanced MR imaging demonstrates abduction-caused hip ischemia and its reversal in piglets. John Caffey Award Paper. AJR Am J Roentgenol. 1996; 166:879-887.
b. **Jaramillo, D.,** Villegas-Medina, O., Laor, T., Shapiro, F., Millis, M.B.: Gadolinium-enhanced MR imaging of pediatric patients after reduction of dysplastic hips: assessment of femoral head position, factors impeding reduction, and femoral head ischemia. AJR Am J Roentgenol.
c. **Jaramillo, D.,** Villegas-Medina, O.L., Doty, D.K., Rivas, R., Strife, K., Dwek, J.R., Mulkern, R.V., Shapiro, F.: Age-related vascular changes in the epiphysis, physis, and metaphysis: normal findings on gadolinium-enhanced MRI of piglets. AJR American Journal of Roentgenology 2004; 182:353-360.
d. Bedoya MA, Jaimes C, Khrichenko D, Delgado J, Dardzinski BJ, **Jaramillo D.** Dynamic gadolinium-enhanced MRI of the proximal femur: Preliminary experience in normal Children. AJR Am J Roentgenol. 2014 Oct; 203(4): W440-6.

2. MR Imaging of Cartilage

Considerable advances have been made in recent years in the evaluation of cartilage structure using MR techniques. T2 and T2* reflect primarily collagen and water content, T1-rho reflects mainly proteoglycan content, and ultrashort TE evaluates the deep layers of the cartilage. In collaboration with Drs. Burstein, Gray and Kim, our work worked on the early implementation of delayed Gadolinium enhanced MR Imaging of Cartilage (dGEMRIC) that selectively evaluates glycosaminoglycan content and fixed charge density. We identified early changes in the hips of older adolescents and young adults with hip dysplasia, that preceeded the radiographic loss of cartilage thickness. We also evaluated whether this technique was feasible in epiphyseal cartilage, and identified the different patterns of zonal enhancement in the growing skeleton in a piglet model. dGEMRIC imaging has become a widely used technique for evaluation of early damage to the

cartilage in children and young adults, particularly in hip disorders such as hip dysplasia and femoro-acetabular impingement.

a. Varich, L.J., Laor, T., **Jaramillo, D.:** Normal maturation of the distal femoral epiphyseal cartilage: age-related changes at MR imaging. Radiology 2000; 214:705-709.
b. Burstein, D., Velyvis, J., Scott, K.T., Stock, K.W., Kim, Y.J., **Jaramillo, D.,** Boutin, R.D., Gray, M.L.: Protocol issues for delayed Gd (DTPA)(2-)-enhanced MRI (dGEMRIC) for clinical evaluation of articular cartilage. Magnetic Resonance in Medicine 2001; 45:36-41.
c. Kim, Y.J., **Jaramillo, D.,** Millis, M.B., Gray, M.L., Burstein, D.: Assessment of early osteoarthritis in hip dysplasia with delayed gadolinium-enhanced magnetic resonance imaging of cartilage. Journal of Bone and Joint Surgery American 2003; 85-A: 1987-1992.
d. Menezes N.M, Olear E.A., Li X., Connolly S.A., Zurakowski D., Foley M., Shapiro F., **Jaramillo D.** Gadolinium-enhanced MR images of the growing piglet skeleton: ionic versus nonionic contrast agent. Radiology. 2006; 239: 406-14.
e. Chu CR, Fortier LA, Williams A, Payne KA, McCarrel TM, Bowers ME, **Jaramillo D.** Minimally Manipulated Bone Marrow Concentrate Compared with Microfracture Treatment of Full-Thickness Chondral Defects: A One-Year Study in an Equine Model. J Bone Joint Surg Am. 2018 Jan 17;100(2):138-146.

3. Imaging of Normal and Abnormal Pediatric Bone Marrow

Marrow transformation occurs in a predictable pattern in children. The skeleton initially is composed entirely of hematopoietic marrow and subsequently becomes fatty. This happens in a predictable pattern: epiphyses, then diaphysis and finally metaphyses. It is important to characterize the relative concentrations of marrow in the skeleton, both qualitatively and quantitatively, in order to differentiate normal marrow from disease and to evaluate the impact of marrow composition on several therapies. I worked with Dr. Mulkern in the quantitative evaluation of the marrow using spectroscopy. I was also the principal investigator in several studies which mapped the age-related changes of the marrow in different bones of the body. Finally, we have done a prospective study in patients with Gaucher using proton spectroscopy in order to determine the fraction of fat in the marrow as a manifestation of response to enzymatic therapy. This is a novel application of proton spectroscopy for this condition. It comes at a time when treatment of Gaucher is being transformed by the use of ceramide analogue inhibitor of glucosylceramide synthase, and it will likely be used in this context.

a. Mulkern, R.V., Meng, J., Oshio, K., Guttmann, C.R., **Jaramillo, D.:** Bone marrow characterization in the lumbar spine with inner volume spectroscopic CPMG imaging studies. Journal of Magnetic Resonance Imaging 1994: 4; 585-589.
b. Mulkern, R.V., Meng, J., Bowers, J.L., Oshio, K., Zuo, C., Li, H., Kraft, R.A., Williamson, D.S., **Jaramillo, D.:** In vivo bone marrow lipid characterization with line scan Carr-Purcell-Meiboom-Gill proton spectroscopic imaging. Magnetic Resonance Imaging 1997; 15:823-837.
c. Laor T, **Jaramillo D**. MR imaging insights into skeletal maturation: what is normal? Radiology. 2009 Jan; 250(1):28-38.
d. **Jaramillo D.,** Bedoya MA, Wang DJ, Pena AH, Delgado J, Jaimes C, Ho-Fung V, Kaplan P. Quantification of bone marrow involvement in treated Gaucher disease with proton MR Spectroscopy: correlation with bone marrow MRI scores and clinical status. AJR Am J Roentgenol. 2015 Jun; 204(6):1296-302.

4. Imaging of Skeletal Disorders in the Fetus

Fetal skeletal imaging has lagged behind other areas of fetal imaging, in part because of limited understanding of the normal appearance of the structures in the fetus and the imaging characteristics of the fetal skeleton. I was the principal investigator in a study of fetal pigs in which we demonstrated the normal prenatal skeletal development on MRI. We also demonstrated how low dose CT could be superior to ultrasound to show severe skeletal abnormalities in the fetus. Our CT protocols are now used in most fetal centers in the United States. Finally, Dr. Victoria and I showed that fetal imaging at 3T is safe and provides superior anatomic information to imaging at 1.5T. We started the widespread use of 3T fetal imaging and now fetal 3T imaging has become common practice. Our group continues to evaluate the sonographic and MR features of skeletal development.

a. Connolly, S.A., **Jaramillo, D**., Hong, J.K., Shapiro, F.: Skeletal development in fetal pigs: MR imaging with histologic correlation. Radiology 2004: 233:505-14,
b. Victoria T, Epelman M, Bebbington MW, Johnson AM, Kramer SS, Wilson RD, **Jaramillo D..** Low-dose fetal CT for evaluation of severe congenital abnormalities: our preliminary experience. Pediatr Radiol. 2012 Jan; 42 Suppl 1:S142-9.
c. Victoria T, Epelman M, Coleman BG, Horii S, Oliver ER, Mahboubi S, Khalek N, Kasperski S, Edgar JC, **Jaramillo D.** Low Dose Fetal CT in the Prenatal Evaluation of Skeletal Dysplasias and Other Severe Skeletal Abnormalities. AJR Am J Roentgenol. 2013 May: 200(5):989-1000.
d. Victoria T, **Jaramillo D,** Roberts TP, Zarnow, D, Johnson AM, Delgado J, Rubesova E, Vossough A. Fetal MRI: jumping from 1.5 to 3Tesla MRI (Preliminary Experience). Pediatr Radiol. 2014 Apr; 44(4):376-86.
e. Victoria T, Johnson AM, Edgar JC, Zarnow DM, Vossough A, Jaramillo D.
f. Comparison Between 1.5-T and 3-T MRI for Fetal Imaging: Is There an Advantage to Imaging With a Higher Field Strength? AJR Am J Roentgenol. 2016 Jan;206(1):195-201.

D. Additional Information: Research Support and/or Scholastic Performance

Ongoing Research Support: None

Completed Research support: None in the last 3 years.