

CURRICULUM VITAE

LAWRENCE M BOYD

3017 Kirkwood Road
Columbia, South Carolina 29205
919-308-9443

email: lboyd@palmettobiomedical.com

EDUCATION

Duke University Durham, North Carolina
Ph.D., Biomedical Engineering, September 2007

Christian Brothers University Memphis, Tennessee
Master of Engineering Management, May 1993

Clemson University Clemson, South Carolina
M.S., Bioengineering, December 1989

Clemson University Clemson, South Carolina
B.S., Mechanical Engineering, December 1987

PROFESSIONAL WORK EXPERIENCE

2007 - Present **Palmetto Biomedical - Columbia, South Carolina**
President and Founder

Palmetto Biomedical provides a wide array of medical device design and consulting services in a range of areas from concept to commercial product.

- Services provided include device and instrument design, prototype fabrication, business plan development, technology evaluation, and device testing guidance.
- Developed and patented a range of devices including those for arthroscopy, foot & ankle surgery, hip replacement, pain management, and local delivery of therapeutic agents. Issued patents for surgical lighting (US Patent D841,209, U.S. Patent 10,458,634), for delivery of therapeutic agents (US Patent 9,642,658) and for a covering/footplate for an external fixator of the lower extremity (U.S Patent 7,887,495).
- Developed medical technology for a variety of orthopaedic and neurosurgical applications. Two spinout ventures have been created utilizing Palmetto Biomedical technology - Bioshape Solutions/Bioclip LLC and View Medical.

2018 - Present **Clemson University - Clemson, South Carolina**
Professor of the Practice - Department of Bioengineering

Teaching and advisory role serving as a guest lecturer, advisor, and team mentor for the curriculum of the Masters of Engineering in Biomedical Engineering degree program. Other roles include assisting BioE faculty who are working toward commercializing technologies being developed in their respective labs and fostering communication between faculty and potential industry partners, technology transfer officers and venture capitalists.

2022 - 2024

Restor3d - Durham, North Carolina

Chief Product Officer

Restor3d is a start-up focused on personalized musculoskeletal care with a particular focus on additive manufacturing, biomaterials, and digital health solutions. Focus products are patient-specific implants and instruments for shoulder, spine, hip, knee and ankle joint replacement and related fusion devices.

- Leadership role, with focus areas that included product innovation and commercialization, strategy and surgeon engagement, design controls and risk management, budgeting and expense management, and team development and education.
- Led integration of Conformis (acquisition) hip and knee teams and projects into the company and focused on building robust planning and reporting for product development across our key portfolios.
- Implemented a process of monthly and quarterly product development team meetings (including key stake holders) and a company-wide stage gate meeting focused on project initiation and launch approval.

2019 - 2022

Bioventus - Durham, North Carolina

Vice President, Product Development

Provided strategic and operational leadership for medical device design and development projects that address unmet clinical needs in Restorative Therapies, Pain Treatments & Joint Preservation, and Surgical Solutions franchises. Products in these areas include EXOGEN® ultrasound-based bone healing system, StimRouter® peripheral nerve treatment system, DUROLANE® hyaluronic acid injectable for knee osteoarthritis and OSTEOAMP® bone allograft.

- Engaged with key opinion leaders (KOLs), consultants, vendors, and FDA regulators. Collaborated with marketing and business development teams to build business cases supporting investments in core technology, IP, people, and processes.
- Coached, mentored, and led 3 teams of 17 engineers and technicians with 4 direct reports in Durham NC, Memphis TN, and Valencia CA.
- Played a key role in guiding our core teams, partnering with project managers, engaging with and communicating with key opinion leaders, guiding small and large animal study designs and organizing surgical labs, interacting with FDA regarding submissions and moving the products toward approval.
- Played an instrumental role in Bioness and Misonix acquisitions by participating in due diligence and leading integration of product development pipeline into Bioventus activities.

2016 - 2018

Spinal Elements - Marietta, Georgia

Executive Vice President, Research & Development

Led the development of products addressing key areas of spinal implant and instrument application (anterior, lateral, posterior access). Led a multi-site R&D team of 25 product development engineers, field engineers, and project managers in Marietta GA and Carlsbad CA. Managed a \$3M+ annual budget.

- Partnered with surgeons on product development efforts including key surgeon identification and engagement, securing development agreements, and managing Technology Assessment Committee submissions.
- Positioned business for compliant operations by establishing SOPs, creating product/launch core teams and leading development of design control and project chartering processes.
- Strengthened IP foundation by partnering with legal counsel to ensure proper IP clearance and timely invention disclosures and patent filings.

2015 - 2016

Medtown Ventures - Atlanta GA & Durham NC

Director

Leadership role in a commercialization and venture consulting firm with a focus on life science, medical device, and biologic technologies. The roles' areas of focus included leading product development activities for a tissue bank, evaluating a novel ceramic surface treatment technology from a leading university, prototyping & intellectual property development for a stem cell sorting microfluidics platform and participation in publications related to a novel cellular bone allograft product.

2013 - 2014

Spine Wave Inc. - Shelton CT and Durham NC

Vice President, Engineering and Business Development

Biologics Division

Business and technical leadership role in identifying suitable biologics to add to Spine Wave's spine product portfolio and bringing the bone grafting products into the company's sales and distribution organization.

- Evaluated a range of biomaterials for spine applications, educated staff and sales force regarding bone grafting and use of bone graft materials, and supported clinical use of the biomaterials.
- Evaluated candidate materials and assisted in negotiation of licensing agreements for exclusive distribution for spine applications.
- Developed the technical support materials for biologics products, including technical monographs, sales training materials and presentations, competitive analysis documents and surgical techniques.
- Developed techniques and instrumentation needed for minimally invasive use of the flowable synthetic biomaterial in spinal applications.

2010 - 2013

Bioshape Solutions - Research Triangle Park, North Carolina

Chief Technical Officer

Company co-founder and co-inventor of the OrthoClip and SpineClip, a novel implant-affixed drug delivery technology for a range of trauma and spine applications. Intellectual property later transferred to Orthoclip LLC.

- Worked with attorneys to draft, file and secure intellectual property (US Patent 9,642,658).
- Secured initial grant funding from NCIDEA (Durham, NC), co-wrote business plan and produced and presented investor presentations at various venture conferences and to investor groups across the U.S.
- Designed initial in vitro and small animal studies and wrote NIH SBIR grant application for Phase I funding.

2007 - 2013

Duke University - Durham, North Carolina

Associate Director, Duke Center for Entrepreneurship and Research Commercialization (CERC)

Adjunct Professor, BME and Engineering Management

Multifunctional role focused on the development of infrastructure to support Duke students with creative and entrepreneurial aspirations. This developmental effort included a student “entrepreneurial hatchery” (DUHatch).

- Developed and taught an interdisciplinary biomedical entrepreneurship class focused on medical device commercialization and business planning (BME 120 - Introduction to Business in Technology Based Businesses).

- Developed and taught an interdisciplinary risk and crisis management class (BME 165 - Managing the Design Process and Controlling Risk with Innovative Technologies: Case Studies and Strategies for Engineers and Managers).
- Developed and taught a leadership class for Masters of Engineering Management students (EGRMGMT 299 – Leading Multifunctional Teams).

2000 – 2007 **Duke University - Durham, North Carolina**
Graduate Teaching Assistant
Graduate Research Assistant

Supported undergraduate engineering classes as a teaching assistant. These activities funded doctoral dissertation education and research. Research partly funded as part of an NIH Pre-Doctoral Fellowship in Cellular and Biosurface Engineering.

1995 – 2000 **Medtronic Sofamor Danek - Memphis, Tennessee**
Vice President, Product Development
Group Director

Experienced product development leader with experience spanning a cross-functional global medical device business. Developed products that grew from nominal sales to over \$100MM at departure. Products included cortical bone dowels, threaded fusion cages, non-threaded cages and mesh, laparoscopic instruments, retractor systems, and lumbar plating systems.

- Product development leader of the Interbody Division from inception. Designed and developed a wide range of devices for interbody fusion, working with all surgical approaches and biomaterial options.
- Primary interface for collaborative efforts involving other MSD product groups such as image guidance, microendoscopic products and posterior spinal fixation systems.
- Presented and supported Company at FDA panel hearings for Interfix® Threaded Fusion Device and for InFuse® System.
- Extensive background in mechanical testing in support of regulatory submissions.
- Led and managed a group of 12 technical professionals and designers supporting global product development for interbody fusion products, including 2 engineers in Paris, France.

1992 – 1995 **Danek Medical - Memphis, Tennessee**
Product Development Manager

Developed Company strategy for interbody fusion and disc arthroplasty. Interacted with multiple key opinion leaders and inventors in developing product portfolio in these areas.

- Performed computer aided design, mechanical testing, and all product development for initial interbody fusion products.
- Built engineering resource around the Michelson technology for threaded and non-threaded devices.
- Primary engineering point of contact for spine surgeon inventor Dr. Gary Karlin Michelson in developing PLIF, ALIF, and translateral systems for interbody fusion.
- Developed early test protocols for interbody fusion and disc arthroplasty. Interface with outside research groups at private foundations and universities.
- Supported publications and presentations for the devices. Presented at multiple global spine technology meetings. Published testing studies in key peer-reviewed journals.
- Recruited and hired initial staffing to build the product development function for the Interbody Group.

1989 - 1992

Dow Corning Wright - Arlington, Tennessee

Product Development Group Leader/Engineer

Directed a group of 5 engineers and technicians. Primary technical support for product line for regulatory, manufacturing, sales and marketing.

- Design and testing of devices for plastic surgery including reconstructive surgery and cosmetic surgery, including prosthetic silicone devices, tissue expanders and mammary implants
- Led product development efforts around small joint implants for hand and foot applications and multiple implants for plastic & reconstructive surgery.
- Primary technical resource for Dow Corning. Product steward for the products within Dow Corning corporate quality system.

PATENTS

1. Boyd, LM, MW Bender and MR Penny (2023) Apparatus for Dilating Bodily Tissue and for Monitoring Neural Activity in the Dilated Body, U.S. Patent 11,730,934, Issued August 22.
2. Boyd, LM and JJ Ratcliffe (2019) Adjustable Surgical Light Device and System, U.S. Patent 10,458,634, Issued October 29.
3. Boyd LM and JJ Ratcliffe (2019) Adjustable Surgical Light Device, U.S. Patent D841,209, Issued February 19
4. Boyd LM, JJ Ratcliffe, J Morin, S Marigowda, TE Adamson, D Robbins and TJ Barbieri (2018) Minimally Invasive Posterolateral Fusion, U.S. Patent 10,022,172, Issued July 17.
5. Boyd LM, JJ Ratcliffe, TE Adamson and PJ Grata (2017) Instrument and System for Placing Graft, Implant and Graft Material for Minimally Invasive Posterolateral Fusion, U.S. Patent 9,775,723, Issued October 3.
6. Boyd LM, Adams SB, Penny MR and C Blazek (2017) Device and Method for Delivery of Therapeutic Agents via Internal Implants, U.S. Patent 9,642,658, Issued May 9.
7. Boyd LM (2013) System and Method for Pretreatment of the Endplates of an Intervertebral Disc, U.S. Patent 8,450,288, Issued May 28.
8. Kozak J, Estes BT and LM Boyd (2013) Anterior Lumbar Plate and Method, U.S. Patent 8,617,224, Issued December 31.
9. Collins K, TG Wilson, J Walkenhorst, D Lee, A Carter, J Pafford, M LoGuidice, L Middleton and LM Boyd (2013) Methods for Injecting a Curable Biomaterial into an Intervertebral Space, U.S. Patent 8,444,694, Issued May 21.
10. Boyd LM, JK Burkus, D Dorchak, BT Estes and EF Ray, III (2011) Intervertebral Spacers with Side Wall Accessible Interior Cavity, U.S. Patent 8,038,714, Issued October 18.
11. Kozak J, BT Estes and LM Boyd (2011) Anterior Lumbar Plate and Method, U.S. Patent 8,016,863, Issued September 13.
12. Foley K, H Ebner, M Liu, C Branch and LM Boyd (2011) Expandable Intervertebral Spacers, U.S. Patent 7,993,403, Issued August 9.
13. Boyd LM and ML Upton (2011) Devices and Methods for the Restoration of the Spinal Disc, U.S. Patent 7,914,537, Issued March 29.

14. Boyd LM, D Kirvin, and SB Adams (2011) Protective and Cosmetic Covering for External Fixators, U.S. Patent 7,887,495, Issued February 15.
15. Boyd LM (2010) System and Method for Pretreatment of the Endplates of an Intervertebral Disc, Issued September 21.
16. Collins K, TG Wilson, J Walkenhorst, D Lee, A Carter, J Pafford, MD LoGuidice, L Middleton and LM Boyd (2010) Methods for Treating Defects and Injuries of an Intervertebral Disc, U.S. Patent 7,740,660, Issued June 22.
17. Collins K, LM Boyd, A Carter, D Lee, J Pafford, J Walkenhorst, TG Wilson, M LoGuidice and L Middleton (2010) Devices for Injecting a Curable Biomaterial into a Intervertebral Space, U.S. Patent 7,722,579, Issued May 25.
18. Bianchi JR, KC Carter, BT Estes, LM Boyd and J A Pafford (2010) Open Intervertebral Spacer, U.S. Patent 7,678,149, Issued March 16.
19. Boyd LM and ML Upton (2009) Devices and Methods for the Restoration of the Spinal Disc, U.S. Patent 7,601,157, Issued October 13.
20. Collins K, TG Wilson, J Walkenhorst, D Lee, A Carter, J Pafford, MD LoGuidice, L Middleton and LM Boyd (2009) Methods for Injecting a Curable Biomaterial into an Intervertebral Space, U.S. Patent 7,556,650, Issued July 7.
21. Boyd LM, JK Burkus, JD Dorchak, BT Estes and EF Ray (2009) Intervertebral Spacers with Side Wall Accessible Interior Cavity, U.S. Patent 7,534,265, Issued May 19, 2009.
22. Branch CL, M Liu, LM Boyd and L Josse (2009) Interbody Fusion Grafts and Instrumentation, U.S. Patent 7,479,160, Issued January 20, 2009.
23. Frey G, M Liu, L Josse and LM Boyd (2008) Devices and Techniques for Lateral Disc Space Approach, U.S. Patent 7,361,193, Issued April 22.
24. Estes BT, Boyd LM and JA Pafford (2008) Open Intervertebral Spacer, U.S. Patent 7,329,283, Issued February 12.
25. Zdeblick T, EF Ray and LM Boyd (2007) Interbody Fusion Device and Method for Restoration of Normal Spinal Anatomy, U.S. Patent 7,238,186, Issued July 3.
26. Boyd LM, EF Ray, BT Estes and M Liu (2007) Method and Instrumentation for Vertebral Body Fusion, U.S. Patent 7,189,242, Issued March 13.
27. Kozak J, BT Estes and Boyd LM (2006) Anterior Lumbar Plate and Method, U.S. Patent 7,060,069, Issued June 13.
28. Boyd LM and ML Upton (2006) Devices and Methods for the Restoration of a Spinal Disc, U.S. Patent 7,004,945, Issued February 38.
29. Boyd LM, EF Ray and J Kozak (2005) Modular Interbody Fusion Implant, U.S. Patent 6,896,701, Issued May 24.
30. Foley K, H Ebner, M Liu, C Branch and LM Boyd (2004) Expandable Intervertebral Spacers, U.S. Patent 6,833,006, Issued December 21.
31. Frey G, M Liu, L Josse and LM Boyd (2004) Devices and Techniques for a Posterior Lateral Disc Space Approach, U.S. Patent 6,830,570, Issued December 14
32. Boyd LM (2004) Reinforced Molded Implant Formed of Cortical Bone, U.S. Patent 6,761,738, Issued July 13.

33. Kozak J, BT Estes, and Boyd LM (2004) Anterior Lumbar Plate and Method, U.S. Patent 6,740,088, Issued May 25.
34. Bianchi J, KC Carter, BT Estes , LM Boyd and JA Pafford (2004) Open Intervertebral Spacer, U.S. Patent 6,695,882, Issued February 24.
35. Zdeblick T, WF McKay, LM Boyd, EF Ray and T McGahan (2003) Spinal Fusion Implants and Tools for Insertion and Revision, U.S. Patent 6,613,091, Issued September 2.
36. Branch, CL, M Liu, LM Boyd and L Josse (2003) Interbody Fusion Implants and Instrumentation, U.S. Patent 6,610,065, Issued August 26.
37. Zdeblick T, LM Boyd and EF Ray (2003) Methods and Instruments for Interbody Fusion, U.S. Patent 6,595,995, Issued July 22, 2003.
38. Boyd LM, EF Ray, BT Estes, JK Burkus and JD Dorchak (2003) Methods and Instruments for Vertebral Interbody Fusion, U.S. Patent 6,575,981, Issued June 10.
39. Boyd LM, EF Ray EF and J Kozak (2002) Modular Interbody Fusion Implant, U.S. Patent 6,468,311, Issued October 22.
40. Boyd LM, EF Ray, BT Estes and M Liu (2003) Method and Instrumentation for Vertebral Interbody Fusion, U.S. Patent 6,428,541, Issued August 6.
41. Bianchi JR, KC Carter, BT Estes, LM Boyd and JA Pafford (2002) Open Intervertebral Spacer, U.S. Patent 6,409,765, Issued June 25.
42. Foley K, H Ebner, M Liu, C Branch and LM Boyd (2003) Expandable Intervertebral Spacers, U.S. Patent 6,395,031, Issued May 28.
43. Zdeblick T, EF Ray, and LM Boyd (2002) Interbody Fusion Device and Method for Restoration of Normal Spinal Anatomy, U.S. Patent 6,375,655, Issued April 23.
44. Pafford JA, LM Boyd, WF McKay, EF Ray and J VanHoeck (2002) Bone Grafts, U.S. Patent 6,371,988, Issued April 16.
45. Rabbe LM and LM Boyd (2002) Adjustable Vertebral Body Replacement, U.S. Patent 6,344,057, Issued February 5.
46. Zdeblick T, LM Boyd and EF Ray (2001) Methods and Instruments for Interbody Fusion, U.S. Patent 6,245,072, Issued June 12.
47. Boyd LM and JA Pafford (2001) Flexible Implant Using Partially Demineralized Bone, U.S. Patent 6,206,923, Issued March 27.
48. Branch CL, LM Boyd and EF Ray (2001) Minimal Exposure Posterior Spinal Interbody Instrumentation and Technique, U.S. Patent 6,200,322, Issued March 13.
49. Foley K, H Ebner, M Liu, CL Branch and LM Boyd (2001) Expandable Intervertebral Spacers, U.S. Patent 6,193,757, Issued February 27.
50. Michelson GK and LM Boyd (2001) Anterior Spinal Instrumentation and Method for Implantation and Revision, U.S. Patent 6,190,388, Issued February 20.
51. Branch CL, M Liu, LM Boyd, and L Josse (2001) Interbody Fusion Grafts and Instrumentation, U.S. Patent 6,174,311 B1, Issued January 16.
52. Michelson GK, LM Boyd and T McGahan (2000), Anterior Spinal Instrumentation and Method for Implantation and Revision, U.S. Patent 6,139,551, Issued October 31.

53. Boyd LM, EF Ray and T McGahan (2000) Template Assembly for Facilitating The Placement of Interbody Fusion Devices, U.S. Patent 6,096,044, Issued August 1.
54. Boyd LM, JK Burkus, and JD Dorchak (2000) Intervertebral Spacers with Side Wall Accessible Interior Cavity, International Patent Publication WO 00/41655, Published July 20.
55. Boyd LM, JK Burkus and JD Dorchak (2000) Truncated Open Intervertebral Spacers, International Patent Publication WO 00/41654, Published July 20.
56. Boyd LM and T McGahan (1998) Anterior Spinal Instrumentation and Method for Implantation and Revision, U.S. Patent 5,797,917, Issued August 25.
57. Boyd LM and EF Ray (1998) Template for Positioning Interbody Fusion Devices, U.S. Patent 5,785,707, Issued July 28.
58. Zdeblick T, EF Ray and LM Boyd (1998) Interbody Fusion Device and Method for Restoration of Normal Spinal Anatomy, U.S. Patent 5,782,919, Issued July 21.
59. Rabbe LM, LM Boyd, JL Chavalier and JC Moreu (1998) Adjustable Vertebral Body Replacement, U.S. Patent 5,776,198, Issued July 7.
60. Rabbe LM, LM Boyd, JL Chavalier and JC Moreu (1998) Adjustable Vertebral Body Replacement, U.S. Patent 5,776,197, Issued July 7.
61. Rabbe LM, LM Boyd, JL Chevalier, and JC Moreu (1997) Adjustable Vertebral Body Replacement, U.S. Patent 5,702,453, Issued December 30.
62. Boyd LM (1997) Anterior Spinal Instrumentation and Method for Implantation and Revision, U.S. Patent 5,683,391, Issued November 4.
63. Zdeblick T, EF Ray and LM Boyd (1997) Interbody Fusion Device and Method for Restoration of Normal Spinal Anatomy, U.S. Patent 5,669,909, Issued September 23.
64. Boyd LM and EF Ray (1997) Template for Positioning Interbody Fusion Devices, U.S. Patent 5,645,549, Issued July 8.
65. Boyd LM, RM Salib and KA Pettine (1996) Intervertebral Disk Arthroplasty Device, U.S. Patent 5,562,738, Issued October 8.
66. Boyd LM, RM Salib and KA Pettine (1995) Intervertebral Disc Arthroplasty, U.S. Patent 5,425,773. Issued June 20.
67. Boyd LM and J Kozak (1995) Anterior Interbody Fusion Device, U.S. Patent 5,397,364. Issued March 14.
68. Boyd LM (1992) Implantable Prosthetic Device with Tethered Valve for Volume Adjustment, U.S. Patent 5,146,933. Issued September 15.

PEER-REVIEWED JOURNAL ARTICLES AND FULL-LENGTH PUBLICATIONS

1. Allen KD, Griffin TM, Rodriguiz RM, Wetsel WC, Kraus VB, Huebner JL, Boyd LM and LA Setton (2009) Decreased Physical Function and Increased Pain Sensitivity in Mice Deficient for Type IX Collagen. *Arthritis & Rheumatism* 60:9, 2684-2693.
2. Boyd LM, Richardson WJ, Allen KD, Flahiff C, Jing L, Li Y, Chen J and LA Setton (2007) Early Onset Degeneration of the Intervertebral Disc and Vertebral Endplate in Mice Deficient in Type IX Collagen. *Arthritis & Rheumatism*,58:1, 164-171.
3. Boyd LM and Carter AJ: (2006) Injectable Biomaterials and Vertebral Endplate Treatment for Repair and Regeneration of the Intervertebral Disc. *European Spine Journal*, 15(Suppl.3):S414-S421.

4. Kitchel SH, Boyd LM and AJ Carter (2006) NuCore Injectable Disc Nucleus, *Dynamic Reconstruction of the Spine*, Ed: Kim DH, Cammisa FP and RG Fessler, Thieme Medical Publishers, New York, pp. 142-145.
5. Boyd LM, Richardson WJ, Chen J, Kraus VB, Tewari A and Setton LA: (2005) Osmolarity Regulates Gene Expression in Intervertebral Disc Cells Quantified with Gene Array and Real-time Quantitative RT-PCR. *Annals of Biomedical Engineering*. 33:8, 1071-1077.
6. Boyd LM, Walkenhorst, J and Carter AJ: (2004) Injectable Biomaterials for Repair and Regeneration of the Intervertebral Disc. *Non-fusion Techniques in Spinal Surgery*, Milan, Italy, September 10-11, 33-41.
7. Boyd LM, Chen J, Kraus, VB and Setton LA: (2004) Conditioned Medium Regulates Matrix Protein Gene Expression in Cells of the Intervertebral Disc. *Spine* 29:20, 2217-2222.
8. Boyd LM, Setton LA, Plouhar PL, Hsu ES, and Richardson WJ: (2003) Animal Models of Disc Degeneration: An Experimental Vertebral Body Defect Model for Human Degenerative Disc Disease. *Non-fusion Techniques in Spinal Surgery*, Bordeaux, France, February 14-15, 55-63.
9. Boyd LM, Mahar A, and Cappello, J: (2003) Injectable Biomaterials for Augmentation of the Nucleus Pulposus. *Non-fusion Techniques in Spinal Surgery*, Bordeaux, France, February 14-15, 83-92.
10. Cizek G and Boyd LM: (2000) Imaging Pitfalls of Interbody Spinal Implants. *Spine*, 25(20): 2633-2636.
11. Boyd LM, Estes BT and Liu M: (1999) Biomechanics of Lumbar Interbody Constructs – Effects of Design and Materials. *Chirurgie Endoscopique et Mini-Invasive du Rachis*, Ed: LeHeuc JC and Husson JL, Sauramps Medical Publishing, Montpellier, France, 181-192.
12. Bouquet P, Boyd LM, Estes BT and Qui Y: (1997) Biomechanical Testing of Interbody Fusion Devices. *Restabilisation Inter-Somatique du Rachis*, Ed: Husson JL and LeHuec JC, Sauramps Medical Publishing, Montpellier, France, pp.75-79.
13. Boyd LM, Heimke G, Vaughan CL and von Recum AF: (1991) An Investigation of Skin Deformation Around Percutaneous Devices. *Clinical Materials* 7:209-217.

PEER-REVIEWED ABSTRACT PROCEEDINGS

1. Tally W and LM Boyd (2016) A Novel Cellular Bone Matrix in Spine Fusion: Safety Profile and Early Clinical Outcomes. International Society for the Advancement of Spine Surgery, April 6-8, Las Vegas, NV, Poster 758-0000-00128.
2. Lonner B, R Banco, R Paxson and LM Boyd (2012) How Does Design and Implantation Technique Effect Load Distribution for Different Lateral Spinal Implants? International Meeting on Advanced Spine Technique, July 18-21, Istanbul, Turkey, Poster ID 671.
3. Boyd LM (2009) Interdisciplinary Education in Engineering Entrepreneurship – Stimulating Innovation and Supporting Entrepreneurial Endeavors on the University Campus. National Collegiate Inventors & Innovators Alliance, March 19-21, Washington, D.C., Poster.
4. Chen J, Boyd LM, Allen KD, Tsuboyama M, L Jing, Malfait A-M and LA Setton (2007) Evaluation of Intervertebral Disc and Vertebral Endplate Degeneration in ADAMTS5 (Aggrecanase-2) Knockout Mice. Osteoarthritis Research Society International World Congress, December 6-9, Ft. Lauderdale, Florida.
5. Boyd LM, Richardson WJ, Odom D, Flahiff CM, Li Y, Guilak F and LA Setton (2007) Microcomputed Tomographic Analysis of Endplate and Vertebral Body Structure in Mice Lacking Type IX Collagen. *International Society for Study of the Lumbar Spine*, Hong Kong, China, June 10-14, paper 26.

6. Boyd, LM, Richardson WJ, Allen K, Flahiff CM, Li Y, Guilak F and LA Setton (2007) Early Onset Degeneration of the Intervertebral Disc and Endplate in Mice Deficient in Type IX Collagen. *International Society for Study of the Lumbar Spine*, Hong Kong, China, June 10-14, paper 27.
7. Boyd, LM, Clapp M, Richardson WJ, Odom DC, Jing L, Chen J, and LA Setton (2007) Static Compression Effects on Region-specific Gene Expression in the Murine Intervertebral Disc In Vitro. *53rd Annual Orthopaedic Research Society*, San Diego, CA, February 11-14, paper 1109.
8. Boyd LM, Clapp M, Richardson WJ, Odom D, Jing L, Chen J and Setton LA. (2006) Static Compression Modulates Gene Expression in the Murine Intervertebral Disc In Vitro. *15th World Congress in Biomechanics*, July 29-August 4, p.6757.
9. Odom DC, Boyd LM and LA Setton (2006) Evaluation of Bone and Marrow Architecture in Type IX Collagen Deficient Mice Using Microcomputed Tomography. *Biomedical Engineering Department Graduation with Distinction Presentation*, Duke University, April 28.
10. Chen J, Jing L, Boyd LM and LA Setton (2006) Intervertebral Disc Cells Respond to Pro-inflammatory cytokine, TNF- α in a Mouse Motion Segment Culture System, *Orthopaedic Research Society*, Chicago, IL, March 19-22, Paper 375.
11. Vishnubhotla S, Goel VK, Shaw MN, Sairyo K, Walkenhorst J and LM Boyd (2006) Kinematic Analysis of Dynamic Stabilization Systems for the Lumbar Spine, *Orthopaedic Research Society*, Chicago, IL, March 19-22, Paper 1278.
12. Clapp M, Boyd, LM, Richardson W, Odom D, Jing L, Chen J and L A Setton (2005) Development of an In Vitro Culture System for Compressive Loading of Intervertebral Discs of the Murine Spine. *State of North Carolina Undergraduate Research Symposium*, Raleigh, NC, November 12.
13. Boyd LM, Richardson WJ, Li Y, Chen J, Flahiff CM, Alexopoulos LG, Guilak F, Xu L, Olsen BR, Bonaldo P and Setton LA (2005) Intervertebral Disc Degeneration in Mice Harboring Collagen Gene Mutations. *International Society for Study of the Lumbar Spine*, New York, NY, May 10-14, p. 224.
14. Chen J, Jing LF, Boyd LM and Setton LA. Intervertebral Disc Cell Responses to Inflammatory Stimuli in a Mouse Motion Segment Culture System In Vitro (2005) *International Society for Study of the Lumbar Spine*, New York, NY, May 10-14, p. 72.
15. Chen J, Jing LF, Boyd LM, Upton ML and Setton LA. Cell Viability and Matrix Protein Gene Expression Levels are Maintained in Mouse Motion Segment Culture (2005) *International Society for Study of the Lumbar Spine*, New York, NY, May 10-14, p.231.
16. Vishnubhotla S, Goel VK, Walkenhorst J, Boyd LM, Vadapilli S and Shaw MN. Biomechanical Advantages of Using Dynamic Stabilization Over Rigid Stabilization (2005) *International Society for Study of the Lumbar Spine*, New York, NY, May 10-14, p.426.
17. Vishnubhotla S, Goel VK, Walkenhorst J, Boyd LM, Vadapalli S, Shaw MN and Sairo K. Stability Offered by an Interspinous Device in Decompression Surgery – A Biomechanical FEM Study (2005) *International Society for Study of the Lumbar Spine*, New York, NY, May 10-14, p.427.
18. Boyd L, Richardson WJ, Li Y, Flahiff CM, Alexopoulos LG, Guilak F, Xu L, Olsen BR, Bonaldo P and Setton LA (2005) Evaluation of Intervertebral Disc Degeneration in Mice Harboring Gene Mutations for Types VI, IX and XI Collagens. *Orthopaedic Research Society*, Washington D.C., February 20-23, Paper 374.
19. Vishnubhotla S, Goel VK, Vadapalli S, Masuda A, Khandha A, Shaw MN, Walkenhorst J, and L Boyd (2004) Dynamic Fixation Systems Compared to the Rigid Spinal Instrumentation – A Finite Element Investigation. *American Society of Biomechanics*, Portland, OR, September 8-11.

20. Ko, P and L Boyd (2004) Gene Expression in Pediatric Intervertebral Disc Cells Quantified with Gene Array and Real-time Quantitative RT-PCR. *Howard Hughes Summer Scholars*, Poster Session, Duke University, July 30.
21. Boyd L, Richardson WJ, Chen J, Kraus VB, and LA Setton (2004) Differences in Expression of Neurotrophic Factors in Adult and Juvenile Intervertebral Disc Cells Subjected to Hyperosmotic Load. *International Society for Study of the Lumbar Spine*, Porto, Portugal, May 30-June 5, p133.
22. Boyd LM, Walkenhorst J, and Cappello J: (2004) An Injectable Biomaterial for Augmentation of the Nucleus Pulposus. *Southeast Workshop on Tissue Engineering and Biomaterials*, Clemson University, Clemson, SC, January 29-20.
23. Boyd LM, Chen J, Richardson WJ, Kraus VB, and Setton LA: (2003) Increased Expression of Brain-Derived Neurotrophic Factor in Intervertebral Disc Cells Subjected to Hyperosmotic Loading. *International Society for Study of the Lumbar Spine*, Vancouver, Canada, May 13-17, p188.
24. Boyd LM, Chen J, Richardson WJ, Kraus VB and Setton LA: (2003) Osmolarity Regulates Gene Expression in Intervertebral Disc Cells Quantified with High Density Oligonucleotide Array Technology. *Transactions of the 49th Annual Meeting of the Orthopaedic Research Society*, New Orleans, LA, February 2-5, 28:1133.
25. Boyd LM, Richardson WJ, Kim J, Plouhar PL, Smith KL, Flahiff CM, Malaviya P, Serhan H, Hsu EW and Setton LA: (2002) Experimental Intervertebral Disc Degeneration Induced by a Vertebral Body Defect. *North American Spine Society*, Montreal, Canada, October 29-November 2, p50.
26. Boyd LM, Richardson WJ, Kim J, Plouhar PL, Smith KL, Flahiff CM, Malaviya P, Serhan H, Hsu EW and Setton LA: (2002) Vertebral Body Damage Induces Intervertebral Disc Degeneration in an Animal Model. *International Society for the Study of the Lumbar Spine*, Cleveland, OH, May 14-18, p22.
27. Boyd LM, Chen J and Setton, LA: (2002) Conditioned Medium Stimulates Aggrecan and Collagen Type II Gene Expression in Anulus Fibrosus Cells. *Transactions of the 48th Annual Meeting of the Orthopaedic Research Society*, Dallas, TX, February 10-13, 27:819.
28. Boyd LM, Grinstaff MW, Smeds KA, Betre H and Setton LA: (2001) Development of a Photocrosslinkable Hyaluronan Hydrogel for Cartilage Repair. *Annals of Biomedical Engineering, BMES Meeting Abstract Supplement*, Durham, NC, October 4-7, 29:S1:160.
29. Baer AE, Grinstaff MW, Smeds KA, Boyd LM and Setton LA: (2001) Nonlinear Finite Element Modeling of Cell Mechanical Environment in Hydrogels for Intervertebral Disc Repair. *Transactions of the American Society of Mechanical Engineers*, 50:113-114.
30. Branch CL, Rauschnig W, Liu M and Boyd LM: (2000) Development and Testing of a Novel Cortical Allograft Wedge for Posterior Lumbar Interbody Fusion. *AANS/CNS Section on Disorders of the Spine and Peripheral Nerves*, Palm Springs, CA, February 23-26, p57.
31. Cizek G and Boyd LM: (1999) Imaging Pitfalls of Interbody Spinal Implants. *North American Spine Society*, Chicago, IL, October 21-23, 15-17.
32. Cizek G and Boyd LM: (1999) Peri-implant Lucencies due to Radiographic Technical Factors. *North American Spine Society*, Chicago, IL, October 21-23, 17-18.
33. Boyd LM, Estes BT and Liu M: (1999) Biomechanical Characteristics of Interbody Constructs: Testing of Titanium, Cortical Bone and Composite Implants. *International Meeting on Advanced Spine Techniques*, Vancouver, Canada, July 8-10.
34. Boyd LM, Estes BT, Bianchi JT and Sutterlin CE: (1999) Biomechanical Characteristics of a Novel Threaded Cortical Bone Dowel. *American Association of Tissue Banks*, New Orleans, LA, August 23-25.

35. Boyd LM: (1998) Threaded Construct Testing. *International Meeting on Advanced Spine Techniques*, Sorrento, Italy, May 1-3.
36. Boyd LM: (1997) Design and Testing of an Intervertebral Disc Prosthesis. *Proceedings 19th International Conference IEEE/EMBS*, Chicago, IL, November 2, 2630-2635.
37. Kitchel SH, Estes BT and Boyd LM: (1997) Threaded Cortical Bone Dowels: Biomechanical Properties and Early Clinical Results. *North American Spine Society*, New York, NY, October 22-25, p29.
38. Kitchel SH and Boyd LM: (1997) Improvement in Sagittal Plane Alignment Following Anterior Lumbar Interbody Fusion with Threaded Titanium Cages. *North American Spine Society*, New York, NY, October 22-25, 108-109.
39. Kitchel SH, Estes BT and Boyd LM: (1997) Threaded Cortical Bone Dowels: Biomechanical Properties and Early Clinical Results. *European Spine Society*, Kos, Greece, September 10-13.
40. Estes BT and Boyd LM: (1997) Mechanical Characteristics and Evaluation of a Novel Threaded Cortical Dowel. *International Meeting on Advanced Spine Techniques*, Hamilton, Bermuda, July 10-12..
41. Boyd LM, Estes BT and Ray EF: (1996) Biomechanical Testing of Interbody Fusion Devices. *International Meeting on Advanced Spine Techniques*, Munich, Germany, June 20-22.
42. Boyd LM and Estes BT: (1995) Biomechanical Testing of Interbody Fusion Devices. *International Meeting on Advanced Spine Techniques*, Curacao, Netherlands Antilles, April 27-28.

INVITED LECTURES

1. "The Value-Added Proposition for BME Masters Programs and Views from Industry" (session co-chair) 5th Biomedical Engineering Educational Summit, New Jersey Institute of Technology, May 30, 2024.
2. "Medical Device Entrepreneurship" GCOM 7291: Frontiers in Biotech II, McIntire School of Commerce, University of Virginia, April 11, 2024.
3. "Standards for Medical Devices, Biologics and Drugs" BMEN 302 Professional Development and Ethics in Biomedical Engineering, Department of Biomedical Engineering, University of South Carolina, February 26, 2024.
4. "Cells, Tissues and Regulatory Affairs", BIOMEDE 5510, Department of Biomedical Engineering, Ohio State University, November 7, 2023.
5. "Commercializing Orthopaedic Medical Devices & Personalized Musculoskeletal Medicine", BIOMEDE 5510, Department of Biomedical Engineering, Ohio State University, October 31, 2023.
6. "Lunch-and-Learn: Careers in Orthopaedic Biomedical Engineering", Department of Bioengineering, Clemson University, October 25, 2019.
7. "The Startup Journey – An Entrepreneurial Adventure", Graduate Program in Bioengineering, Georgia Institute of Technology, December 17, 2018.
8. "Patents & the Individual Inventor", LAWS 722 - Patent Law Course, University of South Carolina School of Law, November 27, 2018.
9. "Adventures in Biomedical Engineering – Industry, Academia and Startups", Graduate Biomedical Engineering Students (BBUGS-LIFE), Georgia Institute of Technology, September 20, 2017.
10. "Careers in Biomedical Engineering", Masters of Biomedical Innovation and Development, Georgia Institute of Technology, March 3, 2017.
11. "Medical Device Entrepreneurship", Biomedical Engineering 4908, Florida International University, Miami, Florida, February 18, 2015.

12. "Entrepreneurship and Intellectual Property", Business Oriented Women Monthly Meeting, Duke University, November 17, 2014.
13. "Entrepreneurship and the Joy of Engineering", Biomedical Engineering 3101, University of Connecticut, Storrs, September 26, 2013, Duke University – Research Experience for Undergraduates, June 18, 2014 and University of Virginia Capstone Design Class, September 9, 2014.
14. "Inventive Drawing", Visual Arts 100.02 – Drawing, Duke University, Durham, NC, October 5, 2011.
15. "Interacting with the Private Sector", Conference on Communicating Science, Greenville, SC, November 4, 2010.
16. "Entrepreneurial Activities in BME", Southeast Biomedical Engineering Career Conference, Clemson, SC, October 29, 2010.
17. "Risk Management: An Engineering Perspective", Fuqua School of Business, Health Sector Management Advisory Council, Durham, NC, April 23, 2010.
18. "Intervertebral Disc Repair and Regeneration" Nuvasive Inc. Board of Directors, Science and Technology Committee, San Diego, CA, February 22, 2010.
19. "How to Start a Medical Device Company", Duke Entrepreneurship Education Series, October 22, 2009.
20. "DUhatch Student Business Incubator", Global Consortium of Entrepreneurship Centers, Rice University, Houston, TX, October 15-17, 2009.
21. "Intellectual Property Basics in Under an Hour", Duke Entrepreneurship Education Series (www.dukedees.com), December 4, 2008.
22. "Writing a Business Plan", One Day Startup, Entrepreneurship Week at Duke University (www.eweekatduke.com), November 22, 2008.
23. "Interdisciplinary Education in Engineering Entrepreneurship", University of Toledo, Department of Biomedical Engineering, September 12, 2008.
24. "Stimulating Innovation and Entrepreneurial Endeavors: An Educational Model", Cleveland Clinic, Department of Neurological Surgery, November 9, 2007.
25. "The Business World – A Game Plan for Your First Year (and Beyond)", Graduate Seminar, Department of Biomedical Engineering, Duke University, February 13, 2006.
26. "Industry, Start-ups and Litigation- Real World Experience", Graduate Seminar, Department of Biomedical Engineering, Duke University, March 25, 2005.
27. "Osmotic Regulation of Gene Expression in Intervertebral Disc Cells", Lumbar Intervertebral Disc Course, AOSpine European Region, Davos, Switzerland, March 17-20, 2005.
28. "The Role of the Endplate in IVD Degeneration", Lumbar Intervertebral Disc Course, AOSpine European Region, Davos, Switzerland, March 17-20, 2005.
29. "Injectable Biomaterials for Repair and Regeneration of the Intervertebral Disc", Lumbar Intervertebral Disc Course, AOSpine European Region, Davos, Switzerland, March 17-20, 2005.
30. "Osmolarity Regulates Gene Expression in Intervertebral Disc Cells Quantified with High Density Oligonucleotide Arrays, Real-time Quantitative RT-PCR and ELISA", Department of Biomedical Engineering, University of Toledo, Toledo, OH, January 23, 2004.
31. "Intervertebral Disc Repair and Regeneration", Neurosurgery Grand Rounds, Wake Forest University, Winston-Salem, NC, April 22, 2003,.

32. "Altered Gene Expression of Intervertebral Disc Cells in Response to Osmolarity Changes", Center for Biomolecular and Tissue Engineering, Duke University, Durham, NC, April 3, 2003.
33. "Developing a System for Repair and Regeneration of the Intervertebral Disc", Elon University, Elon, NC, February 21, 2003.
34. "Biomechanics of Anterior Cages: Threaded and Upright", The Surgical Management Disorders, Beaver Creek, CO, January 17, 1999.
35. "Deminerlized Bone Matrix – Background, In Vivo Studies and Clinical Experience", Clinical Update: Lumbar Interbody Fusion 1997 and Beyond, Seattle, WA, November 15, 1997
36. "Biomechanical Testing of Interbody Fusion Constructs", Clinical Update: Lumbar Interbody Fusion 1997 and Beyond, Seattle, WA, November 15, 1997
37. "Medical Devices: Product Development Process", Clinical Biomechanics of the Spine Course Lecture, University of Iowa, Iowa City, IA, March 18, 1997.
38. "Interactions with Students at Sofamor Danek", Workshop on Industrial Interactions, Biomedical Engineering Society, Pennsylvania State University, State College, PA, October 4, 1996.
39. "Biomechanical Testing of Interbody Fusion Devices", Total Spine: Advanced Concepts and Constructs, Cancun, Mexico, February 1, 1995.
40. "Design Rationale and Biomechanical Testing of Interbody Fusion Devices", Total Spine: Advanced Concepts and Constructs, Cancun, Mexico, January 27, 1995.
41. "Spine Disc Prostheses", Graduate Seminar in Biomedical Engineering, Department of Biomedical Engineering, University of Iowa, Iowa City, IA, September 1, 1994.

HONORS AND AWARDS

- | | |
|------|---|
| 2015 | College of Fellows, American Institute for Medical and Biological Engineering |
| 2007 | Dean's Award for Mentoring, Graduate School, Duke University |
| 2007 | Graduate Certificate in Center for Biomolecular & Tissue Engineering, Duke University |
| 2002 | Teaching Grant, Boyd LM, Driscoll S and Mitchell S, "Initiation of a Teaching Engineering Discussion Group for BME Graduate Students", Center for Teaching, Learning and Writing, Duke University |
| 2001 | NIH Pre-Doctoral Fellowship in Cellular and Biosurface Engineering, Center for Cellular and Biosurface Engineering, Duke University |
| 1987 | Tau Beta Pi Engineering Honor Society, Clemson University |

PROFESSIONAL SERVICE ACTIVITIES

- | | |
|------|--|
| 2023 | Adjunct Professor, Joint Department of Biomedical Engineering, North Carolina State University and University of North Carolina at Chapel Hill |
| 2018 | SCLaunch Resource Partner, SCRA Academic Collaboration Team & MDCAP Committee Member, South Carolina Research Authority |
| 2006 | Reviewer, <u>Medical Engineering & Physics</u> and <u>Journal of Biomechanics</u> |
| 2005 | Session Moderator, Lumbar Intervertebral Disc Course, AOSpine, Davos, Switzerland |
| 2004 | Session Moderator, Non-fusion Techniques in Spinal Surgery, Milan, Italy |
| 2003 | Session Moderator, Non-fusion Techniques in Spinal Surgery, Bordeaux, France. |
| 1997 | Novus LC Interbody Fusion Device Orthopaedic Panel Hearing, U.S. Food and Drug Administration, Washington, D.C., December 11 |
| 1992 | Secretary, Memphis Biomedical Engineering Society |

TEACHING EXPERIENCE

- Lecturer and Mentor, November 2018 to Present, BIOE 8600/8610 Biomedical Engineering Device Design Innovation and Product Translation, Clemson University (Enrollment 30).
- Instructor, Spring 2009 to June 2013, Introduction to Entrepreneurship Module, Duke Center for International Development, Duke University (Enrollment 30).
- Instructor, Spring 2008 to June 2013, BME 165/EGRMGMT 299, Managing the Design Process and Controlling Risk with Innovative Technologies: Case Studies and Strategies for Engineers and Managers, Duke University (enrollment 10).
- Instructor, Spring 2008, Fall 2009, SOC 192, Independent Study (Market assessment and business plan development), Duke University (Enrollment 2).
- Instructor, Fall 2007 to June 2013, BME 120, Introduction to Business in Technology-based Companies, Duke University (enrollment 30).
- Instructor, Fall 2007 to June 2013, EGRMGMT 299, Leading Multi-functional Teams in Technology-based Companies, Duke University (enrollment 7)
- Guest Lecturer, Fall 2005 to June 2013, BME 227, Biotechnology and Biological Device Design, Duke University
- Instructor, Spring 2005, BME 227, Biotechnology and Biological Device Design, Duke University (enrollment 14)
- Teaching Assistant, 2001 - 2002, BME 083, Introduction to Biomaterials, Duke University (enrollment 45-55)
- Sales Training Instructor, 1994-2000, Medtronic Sofamor Danek, Memphis, Tennessee.

PROFESSIONAL AFFILIATIONS (PAST AND PRESENT)

Biomedical Engineering Society
American Orthopaedic Foot & Ankle Society
North American Spine Society
Orthopaedic Research Society

INTERESTS AND ACTIVITIES

Member, Eastminster Presbyterian Church
Tennis & Pickleball
Quail Hunting
Fishing
Hiking and Bird Watching
Architecture
American History