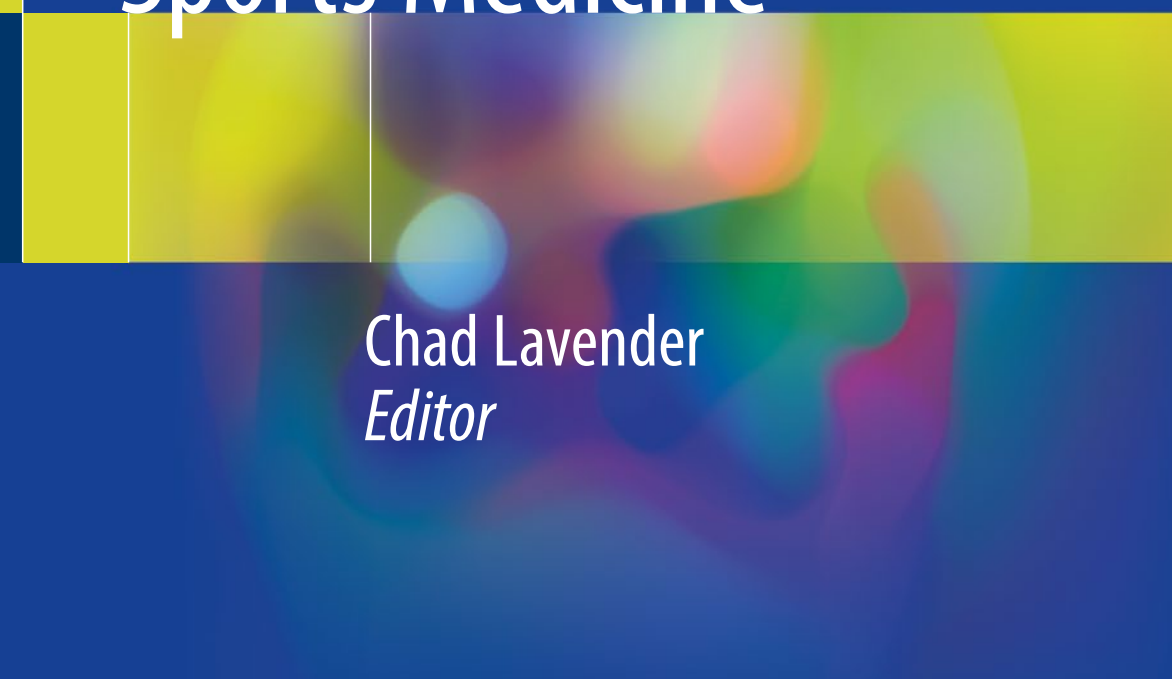
# Biologic and Nanoarthroscopic Approaches in Sports Medicine



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*Editor*

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# Foreword

It is an honor to write the foreword for Dr. Chad Lavender's first of what will likely be many books. It is thrilling and with great pride that we, the faculty members and past graduates of Orthopedic Research of Virginia, see and read this incredible book filled with state-of-the-art arthroscopic techniques. The highlights of the book are its educational insights into appropriate uses of orthobiologics and their application with the most minimally invasive tool to date, the nanoscope. While much research has been done and is yet to be done, the road map is clear, orthobiologics will continue to play a greater and greater role in the treatment of orthopedic pathologies. The procedure presentations starting with the ACL and then the nanoscope are stunning. Surely you will agree, Dr. Lavender and his talented host of contributors are deserving of our utmost congratulations on a job well done. It has been truly fascinating over the past 30 years to have witnessed the "age of the arthroscope." Many books and articles have chronicled the unprecedented march of technology and this book beautifully adds to the timeline of success. The unparalleled developments in arthroscopy is the product of conscientious and tireless efforts of many pioneers. All of us have been the beneficiaries of these efforts and we all have pioneers who mentored and assisted us in our journey with the arthroscope. At ORV, we were blessed with mentors like Dick Caspari, Rick Meyers, and Terry Whipple. But let's not forget our many partners including our industry and scientific colleagues who have equally helped pave the way to ever improved patient care. In the ORV tradition of technique development and refinement, Dr. Lavender has pushed the envelope to logical and exciting new heights. These achievements remind us that it was not so long ago when Dr. Caspari developed the arthroscopic trans-glenoid shoulder stabilization and Dr. Whipple began the arthroscopic treatment of wrist instability. These are exciting times to be an arthroscopist, and this progress has advanced the arthroscope past the treatment of "sports injuries" to the treatment of common and uncommon orthopedic problems. Cheers to Chad and his fellow authors and cheers to the past, present, and future of arthroscopic surgery.

William R. Beach, MD
Director of Orthopaedic Research of Virginia
Former AANA President
Richmond, Virginia

# Preface

"Never skip a step"

**Dr. Chad Lavender**

Dear colleagues,

As orthopedic surgeons specializing in sports medicine, we have a unique opportunity to see the outcomes of our work in the field of play. This drives us to improve our practices in order to help patients have faster recoveries and return to play at higher levels. We work in a high-risk, high-reward field and one that is constantly changing. Obviously, you would not be reading this text if you were not interested in the development of novel techniques, the use of the latest biologics and minimally invasive procedures. The ideas behind this book started with a single conversation between myself and several Arthrex representatives, Aaron Ferguson, Shawn George, and Tyler Walker discussing how to improve ACL techniques with the use of biologics. Now, 3 years later, this book is a combination of not just those procedures but also methods that use cutting-edge technologies, such as the nanoscope. We at Marshall University are striving to continue to create innovative techniques,

publish them, and help educate other surgeons on the utility and usefulness in order to incorporate them into practice.

Two parts create this book. Part one focuses on biologic advancement throughout different conditions. Part two focuses on nanoscopic techniques and how arthroscopy is changing into a more minimally invasive approach. Our hope is that surgeons will read this book and choose certain elements of the techniques in order to create new advancements to enhance our field. In this first edition, we are introducing new methods such as the use of biologics in ACL reconstruction, as well as introducing reconstructions and repairs using a nanoscope. We look forward to continuing to study the outcomes in clinical trials and refining the techniques as new technology arises.

I thank and acknowledge the patients and their families who have trusted us with their care while we develop these groundbreaking techniques. I also want to thank the residents, fellows, and attending physicians who have given their time to compose chapters for this book.

Scott Depot, WV, USA Chad Lavender

# Acknowledgements

I would like to take this opportunity to acknowledge all of those who have had a role in my training and my development as an orthopedic surgeon. I was fortunate to have remarkable coaches and professors at West Virginia University throughout undergraduate and medical school. Later, I began my residency at Marshall University, which provided me the opportunity to excel and train in orthopedics. Special thank you to Dr. Charles Giangarra, my biggest mentor. Additionally, I had an outstanding fellowship program at the Orthopaedic Research of Virginia. During fellowship, I developed the drive to create new techniques, which you will read in the following chapters. Certainly, without the authors of the chapters, I would be unable to present this book. Therefore, we are grateful for those at Marshall University, the residents, and attending physicians who have participated in composing this text. Also special thanks to Dr. Akhavan and his fellows at the Orthopaedic Sports Medicine Fellowship at Allegheny General Hospital as well as Dr. Caldwell and his fellows at the Orthopaedic Research of Virginia. I am very thankful that these two exceptional programs helped to facilitate the creation of the first edition of this book.

As it relates to the contents of this book and the creation of the techniques, numerous people have contributed in providing important tools and ideas, which helped refine these techniques. Special acknowledgments to our local representatives, Aaron Ferguson, Cameron Guill, and Mike Molina, as well as our regional representatives, Dave Hawkins, Shawn George, Tyler Walker, John Parulski, and Bart Kayser. I would also like to acknowledge the corporate representatives at Arthrex: Chelsea Day, Robert Benedict, Ryan Keller, and the owner Reinhold Schmieding. Each of these individuals played a role either in the day-to-day development of these techniques or the overall conceptualization of the techniques. They truly helped fuel our passion to enhance these methods, which ultimately will lead to improved patient outcomes.

It is especially important to acknowledge our sports team, both in the operating room and clinically. The OR staff has had patience as we developed each technique and continually revised them. It has not been easy to develop novel techniques and I can attest that each of them helped develop certain pearls that led to the success. I would also like to thank my staff in the clinic, starting with my nurse practitioner, Kara Cipriani, who has helped me with every aspect of our practice, including research for the past 6 years. Special thank you to Ginger Peters, my office manager

who has worked tirelessly to maintain our high practice standards. Additionally, thank you to my other clinic staff who are involved in our daily activities. Many thanks to Chad Fisher and Dr. Ali Oliashirazi for their exceptional support and guidance in our clinical practice.

I would like to acknowledge my parents, David and Patty Lavender, who provided the opportunity for me to attend medical school to begin this journey and helped instill in me the characteristics that I still use today in practice. To my wife, Michelle, my son, Chance, and daughter, Louren, who have allowed me to spend thousands of hours on the videos and development of techniques, I am forever grateful. They truly have an understanding for my passion to improve patient outcomes.

Finally, and most importantly, I would like to acknowledge each of my athletes and patients who trusted me to perform and utilize the new techniques to enhance their recovery. They are an inspiration and make my career rewarding; it is because of them that I am able to provide you with this textbook.

# Contents

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# Part I

# Advanced Biologic Techniques in Sports Medicine

# Biologics in Sports Medicine

1

Galen Berdis and John Jasko

## Introduction

Over the past several years, the use of biologic therapies has become popular for a wide range of sports medicine injuries and other orthopedic-related diseases including tendon injury or inflammation, ligamentous injury, cartilaginous injury, and osteoarthritis. These biologic treatment options are often autologous in nature, of which the two most popular are platelet-rich plasma and mesenchymal stem cells that are most commonly harvested from bone marrow concentrate. The FDA does not currently regulate the use of bone marrow concentrate or platelet-rich plasma as they fall outside of the scope of what the FDA considers human cells, tissue, and cellular and tissue-based products (HCT/Ps) in title 21, part 1271, of the Code of Federal Regulations (CFR), and therefore the use of both PRP and BMC has been expanding in clinical practice [1]. It is important that both PRP and BMC should be registered and taken through the proper protocols established by the FDA [2, 3].

## Platelet-Rich Plasma

PRP is made up of platelets, plasma, leukocytes, monocytes, and neutrophils each with associated growth factors [4]. As the most numerous cell in PRP, platelets release substantial amounts of insulin-like growth factor 1 (IGF-1), transforming growth factor β (TGF-β), platelet-derived growth factor (PDGF), fibroblast growth factor (FGF), epidermal growth factor (EGF), and vascular endothelial growth

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factor (VEGF) [4]. The rationale behind the use of PRP for treatment is that platelets are the first to arrive at the site of tissue injury and thus have the potential to release growth factors that play a critical role in mediating healing [5]. PRP has been used during surgery at sites of tendon repair and reconstructions such as rotator cuff repairs and anterior cruciate ligament (ACL) reconstructions.

## Bone Marrow Concentrate

Bone marrow concentrate (BMC) differs from PRP in that it attempts to harness the healing value of mesenchymal stem cells. Bone marrow has become an excellent source to harvest stem cells due to its easy accessibility and sufficient quantities for clinical use without the need for ex vivo expansion [6]. For clinical use, bone marrow may be harvested as can be read in several techniques throughout this book, and concentrated through a method involving centrifugation. Through the development of the Arthrex (Naples, Fl) Angel system BMC can now be harvested and used during surgery within minutes. There are several sites to harvest bone marrow, but we prefer the proximal tibia for knee procedures. A second major source of MSCs which is used in clinical practice is adipose tissue, which is not discussed in this chapter as it is not a current source of MSCs in the techniques described in later chapters [7]. The rationale behind the use of BMC derived MSCs is that these cells have the potential to regenerate tissue directly through differentiation into cell lineages of the tissues in which they are placed such as damaged ligament, tendon or cartilage and may indirectly facilitate healing through stimulation of angiogenesis and recruiting local tissue-specific progenitors [8].

## Clinical Use of PRP and BMC

Despite inconsistent evidence to support the use of PRP and BMC for the treatment of various sports-related injuries, their clinical use has been wide and continues to expand. Current indications include use during ligament reconstruction to promote healing response, promotion of healing response in tendinopathy, use in treatment of osteoarthritis, and treatment of osteochondral damage.

The use of biologics in ACL reconstruction has been studied but mainly centered on the use of PRP. A systematic review conducted by Vavken et al. which included eight studies found that “the addition of platelet concentrates to ACL reconstruction may have a beneficial effect on graft maturation and could improve it by 20–30% on average” [9]. In an MRI-based single-blinded prospective study, regarding time to tendon healing, Radice et al. found that PRP augmented ACL reconstruction required only 48% of the time to achieve a homogenous healed graft compared to non-PRP group [10]. Vascular endothelial growth factor (VEGF), which can be found in PRP, has been studied in its role for angiogenesis in ACL reconstruction. Takayama et al. demonstrated that blocking VEGF will

reduce angiogenesis after ACL reconstruction, prevent graft maturation, and reduce biomechanical strength following ACL reconstruction [11]. Throughout this book you will see BMC used in a variety of applications to hopefully improve ligament and cartilage reconstructions and repairs. The theory is BMC will show even enhanced results from those focused on PRP and VEGF mentioned above.

PRP and BMC have been used in clinical practice to treat tendon injury and tendinopathy although there is limited evidence of improved outcomes in the literature. In a recent meta-analysis of the use of biologics in rotator cuff pathology, Randelli et al. concluded that 13 clinical trials from 2011 to 2014 utilizing PRP for rotator cuff tear repairs have provided controversial results and that research regarding the use of MSCs in shoulder surgery is limited [12]. The single identified human pilot trial in the meta-analysis was performed by Ellera Gomes et al. which enrolled 14 patients who underwent augmented RTC repair with autologous bone marrow concentrate aspirated from iliac crest with all 14 patients showing tendon integrity at minimum 12-month follow up on MRI [13].

Epicondylitis has been a common application of the use of PRP, with lateral epicondylitis more extensively studied than medial. A meta-analysis was performed by Arirachakaran et al. in 2016 which identified ten studies that met inclusion criteria. The authors concluded that PRP significantly improved pain and Patient-Related Tennis Elbow Evaluation scores when compared with autologous blood or corticosteroid injection for the treatment of lateral epicondylitis [14]. BMC has been less extensively studied for use in tendinopathy than PRP; however, one small study with 8 patients at 5-year follow up showed that 7 out of 8 patients had excellent results after ultrasound-guided inoculation of the patellar tendon from iliac crest harvested bone marrow concentrate [15].

Many practitioners have begun to utilize PRP and BMC in their treatment of knee osteoarthritis. In their literature review, Lamplot et al. identified 12 level 1 studies that utilized platelet-rich plasma in the setting of knee osteoarthritis many of which show promising results for pain and knee scores when comparing PRP to hyaluronic acid or saline placebo control [16]. A systematic review by Chalha et al. identified 11 studies of BMC use in knee OA and osteochondral injuries. Three of these studies showed good or excellent results for BMC use in knee OA and 8 of the studies showed good or excellent results in the treatment of focal chondral defects [17]. At this time, the American Academy of Orthopaedic Surgeons (AAOS) in their clinical practice guidelines currently does not recommend for or against the use of PRP for the treatment of knee osteoarthritis due to lack of sufficient evidence.

Despite the lack of conclusive evidence regarding the benefit of PRP and BMC use in the aforementioned sports-related pathology, there have been very promising results in the literature that warrant further well-designed randomized controlled trials. Surgeons continue to treat patients with PRP and BMC and have developed new and exciting surgical techniques to utilize their healing potential. This book demonstrates many different emerging techniques for the treatment of sports-related injuries and will highlight the use of biologics with various surgical interventions.

## References


1. Food and Drug Administration. Regulatory Considerations for Human Cells, Tissues and Cellular and Tissue-Based Products: Minimal Manipulation and Homologous Use. Washington, DC: US Department of Health and Human Services; 2017.
2. LaPrade RF, Geeslin AG, Murray IR, et al. Biologic treatments for sports injuries II think tank – Current concepts, future research, and barriers to advancement, part 1: Biologics overview, ligament injury, tendinopathy. Am. J. Sports Med. 2016;44(12):3270–83.
3. Food and Drug Administration. Guidance for Industry Current Good Tissue Practice (CGTP) and Additional Requirements for Manufacturers of Human Cells, Tissues, and Cellular and Tissue-Based Products (HCT/Ps). Washington, DC: US Department of Health and Human Services; 2011.
4. Wasterlain AS, Braun HJ, Dragoo JL. Contents and formulations of platelet-rich plasma. Operat Tech Orthop. 2012;22:33–42.
5. Creaney L, HamiltonGrowth B. Factor delivery methods in the management of sports injuries: The state of play. Br. J. Sports Med. 2008;42:314–20.
6. Murray IR, Corselli M, Petrigliano FA, Soo C, Peault B. Recent insights into the identity of mesenchymal stem cells: Implications for orthopaedic applications. Bone Joint J. 2014;96(3):291–8.
7. Aust L, Devlin B, Foster SJ. Yield of human adipose-derived adult stem cells from liposuction aspirates. Cytotherapy. 2004;6(1):7–14.
8. Anz AW, Hackel JG, Nilssen EC, Andrews JR. Application of biologics in the treatment of the rotator cuff, meniscus, cartilage, and osteoarthritis. J. Am. Acad. Orthop. Surg. 2014;22(2):68–79.
9. Vavken P, Sadoghi P, Murray MM. The effect of platelet concentrates on graft maturation and graft-bone interface healing in anterior cruciate ligament reconstruction in human patients: A systematic review of controlled trials. Arthroscopy. 2011;27(11):1573–83.
10. Radice F, Yanez R, Gutierrez V, Rosales J, Pinedo M, Coda S. Comparison of magnetic resonance imaging findings in anterior cruciate ligament grafts with and without autologous platelet-derived growth factors. Arthroscopy. 2010;26(1):50–7.
11. Takayama K, Kawakami Y, Mifune Y, et al. The effect of blocking angiogenesis on anterior cruciate ligament healing following stem cell transplantation. Biomaterials. 2015;60:9–19.
12. Randelli P, Randelli F, Ragone V, et al. Regenerative medicine in rotator cuff injuries. Biomed. Res. Int. 2014;2014:129515.
13. Ellera Gomes JL, da Silva RC, Silla LM, Abreu MR, Pellanda R. Conventional rotator cuff repair complemented by the aid of mononuclear autologous stem cells. Knee Surg. Sports Traumatol. Arthrosc. 2012;20(2):373–7.
14. Arirachakaran A, Sukthuayat A, Sisayanarane T, Laoratanavoraphong S, Kanchanatawan W, Kongtharvonskul J. Platelet-rich plasma versus autologous blood versus steroid injection in lateral epicondylitis: Systematic review and network meta-analysis. J. Orthop. Traumatol. 2016;17(2):101–12.
15. Pascual-Garrido C, Rolon A, Makino A. Treatment of chronic patellar tendinopathy with autologous bone marrow stem cells: A 5-year follow up. Stem Cells Int. 2012;2012:953510.
16. Lamplot JD, Rodeo SA, Brophy RH. A practical guide for the current use of biologic therapies in sports medicine. Am. J. Sports Med. 2020 Feb;48(2):488–503.
17. Chahla J, Dean CS, Moatshe G, Pascual-Garrido C, Serra Cruz R, LaPrade RF. Concentrated bone marrow aspirate for the treatment of chondral injuries and osteoarthritis of the knee: A systematic review of outcomes. Orthop. J. Sports Med. 2016;4(1):2325967115625481.