Emerging trends in elbow injury, pathology and treatment

The elbow is a complex joint that is critical for proper function of the upper extremity. The elbow joint is susceptible to a variety of different pathologies, and even minor injuries can lead to severe disability. Due to its complexity, the elbow is challenging to study and remains understudied compared to other joints in the body. More research is needed to better understand healthy elbow function, elucidate the etiology of common injuries, and develop novel treatment techniques that can fully restore elbow use following pathology. This series seeks to bring more attention to the topic of elbow research and focuses on emerging trends in elbow injury, pathology and treatment. The invited review papers describe various elbow conditions, recent advancements that have been achieved in treatment strategies, and potential opportunities to further elucidate pathogenesis of, and therapies for, common clinical conditions of the elbow joint.

Singh *et al.* provide a thorough overview of elbow anatomy and the structures that contribute to the inherent stability of the joint. The authors then discuss several common elbow injuries including simple elbow dislocations, fracture dislocations, and joint instability. A review of important principles related to assessment/diagnosis is followed by a detailed discussion of treatment strategies for these elbow conditions. Clinicians and basic science researchers alike will appreciate this detailed guide to the pathoanatomy of elbow dislocation and instability, which will be useful for developing a better understanding of mechanisms of elbow stability and successful treatment strategies for these clinical conditions.

Joint contracture is a common condition of the elbow that causes debilitating loss of motion. Two papers in this series cover this unpredictable and challenging condition. Hildebrand *et al.* discuss non-surgical approaches for preventing and treating elbow contracture. The authors describe how non-surgical strategies may help prevent joint contracture from developing or serve as adjuncts to surgical interventions to restore motion loss. To date, preclinical models have been used to target inflammation, growth factors, cells (fibroblasts and myofibroblasts), collagen and hyaluronic acid, with some studies showing promising results in reducing fibrosis and motion loss. Although most preclinical strategies have not yet been successfully translated to clinical practice, the authors recommend a collaborative, multi-faceted approach (i.e., *in vitro* studies, *in vivo* animal models, large randomized clinical trials and knowledge translation) to facilitate development of innovative clinical techniques. Papadopoulos *et al.* present an overview of surgical approaches for the release of capsular tissue in contracted elbows, with the goal of restoring functional range of motion to the joint. The authors describe arthroscopic release as well as open techniques based on lateral, medial, anterior or posterior approaches. The authors recommend individualized surgical management plans since each patient/injury is unique. Currently, the authors use a combined surgical technique for treating elbow stiffness, although they acknowledge that further study is needed to fully evaluate the risks and benefits of each technique.

Pooley and Van der Linden discuss total elbow replacement (TER) arthroplasty in the context of treating arthritis. They provide a fascinating historical overview of TER development and explain how development of designs for elbow replacement have proved to be more challenging than for other joints (e.g., knee, hip, etc.) due to the anatomical and mechanical complexity of the elbow. The use of TER has shifted in recent decades from being used primarily for treating arthritis to being used more frequently for elbow trauma. Recent evidence regarding patterns of cartilage wear/degeneration in elbow arthritis as well as potential benefits to treating the humeroulnar and radiocapitellar articulations as distinct joints are likely to lead to advanced developments in treatment approaches and implant design for both arthritis and trauma. Related to this study, Langohr and Willing provide a review of the biomechanical impact of prosthesis reconstruction of the elbow joint. The authors describe various types of elbow reconstruction including hemiarthroplasty (of either the distal humerus or radial head) and total joint arthroplasty, which replaces both the distal humerus and the proximal radius/ulna. TER can reduce pain and restore joint motion; however, these surgical procedures can cause several issues including altered biomechanics (e.g., cartilage contact patterns, joint kinematics, etc.), potential for joint instability, excessive wear of remaining cartilage, and breakdown of implant materials. This paper outlines how these issues can be impacted by implant design/materials, anatomical positioning, and soft tissue status. While current approaches for prosthesis reconstruction are beneficial, the authors suggest that optimization of implant geometry (i.e., size, shape), material (i.e., more compliant) and surgical placement may improve long-term prognosis following TER.

Given the large increase in ulnar collateral ligament (UCL) injuries and reconstructions in recent years, Smith and Bernholt provide a timely review of this clinical condition. Their paper describes the anatomy and biomechanics of the UCL and then provides a detailed overview of non-surgical and surgical treatment of UCL injuries. While surgical treatments for UCL tears generally provide a robust ligament graft, these reconstructions don't always restore pre-injury elbow function, which is critical for high-performance athletes (i.e., baseball pitchers) that are most commonly affected by this injury. The authors outline several topics that should be considered in future research including better surveillance to improve injury prevention and biomechanical studies to relate joint motions to tissue-level damage, which could help enhance reconstruction and rehabilitation of damaged UCLs.

Finally, two papers in this series provide overviews of tools that can be used to study elbow conditions: preclinical models and computational models. David *et al.* discuss the use of preclinical models to study the elbow joint. Their review outlines *in vitro* and *in vivo* preclinical models that have been developed to recapitulate common elbow conditions and describes the relative strengths and weaknesses of these approaches. As the overall availability of useful preclinical models is limited, the authors also provide recommendations for the development of future preclinical models. The promise and potential of validated preclinical models to help in developing novel intervention strategies to improve the treatment of elbow diseases in human patients is summarized. Stylianou presents an overview on computational based approaches for simulating the biomechanics of the elbow joint. Although computational models have been extensively used to understand injury patterns and mechanics of other joints (e.g., knee and hip), they have been underutilized in evaluating the elbow and corresponding tissue structures. This review paper describes the two primary approaches that have been used to date, namely the finite element method and multibody models, to analyze ligament behavior, cartilage contact forces/patterns, and relationships between periarticular elbow tissues. Adequate validation of computational models remains a challenge; however, these approaches are capable of simulating aspects of elbow motion and mechanics that are impossible to consider otherwise. Continued work with these and other modeling approaches will enhance clinical utility and relevance.

We hope that readers will enjoy the articles contained within this series and that these papers will encourage clinicians, scientists and engineers to pursue research projects that can enhance our understanding of debilitating elbow conditions and develop novel treatment strategies to improve joint function.

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Spencer P. Lake

Spencer P. Lake, PhD
Department of Mechanical Engineering & Materials Science, James McKelvey School of Engineering,
Washington University in St. Louis, St. Louis, MO, USA.
(*Email: lake.s@wustl.edu*)
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