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Donald D. Anderson

Biomechanics and Tribology of Total Ankle Replacement 1

Claire Brockett

This article discusses the biomechanics and tribology of total ankle replacements considering the influence of implant design and generation on functional outcome, before discussing the interplay between biomechanics and tribology in the clinical success of total ankle replacement. It reflects on what we know and highlights areas for further research, as well as identifying factors to consider in clinical practice.

Diabetic Foot Considerations Related to Plantar Pressures and Shear 13

Jessi K. Martin and Brian L. Davis

Diabetic foot ulcers are a complex, multifaceted, and widespread complication of diabetes mellitus. Although there are a multitude of risk factors contributing to diabetic foot ulcer development, pressure and (more recently) shear stresses are two biomechanical metrics that are gaining popularity for monitoring risk factors predisposing skin breakdown. Other areas of diabetic foot ulcers under research include plantar temperature measuring, as well as monitoring wear-time compliance and machine learning/AI algorithms. Charcot arthropathy is another diabetes complication that has a relationship with diabetic foot ulcer development, which should be monitored for development alongside ulcer development. The ability to monitor and prevent diabetic foot ulcer development and Charcot neuroarthropathy will lead to increased patient outcomes and patient quality of life.

Biomechanical Implications of Congenital Conditions of the Foot/Ankle 27

Karen M. Kruger, Peter A. Smith, and Joseph J. Krzak

Segmental foot and ankle models are often used as part of instrumented gait analysis when planning interventions for complex congenital foot conditions. More than 40 models have been used for clinical analysis, and it is important to understand the technical differences among models. These models have been used to improve clinical planning of pediatric foot conditions including clubfoot, planovalgus, and equinovarus. They have also been used to identify clinically relevant subgroups among pediatric populations, quantify postoperative outcomes, and explain variability in healthy populations.

Role of Robotic Gait Simulators in Elucidating Foot and Ankle Pathomechanics 45

William R. Ledoux

Testing with cadaveric foot and ankle specimens began as mechanical techniques to study foot function and then evolved into static simulations of specific instances of gait, before technologies were eventually developed to fully replicate the gait cycle. This article summarizes the clinical applications of dynamic cadaveric gait simulation, including foot bone kinematics and joint function, muscle function, ligament function, orthopaedic foot and ankle pathologies, and total ankle replacements. The literature was reviewed and an in-depth summary was written in each section to highlight one of the more sophisticated simulators. The limitations of dynamic cadaveric simulation were also reviewed.

Biomechanical Insights Afforded by Shape Modeling in the Foot and Ankle 63

Amy L. Lenz and Rich J. Lisonbee

Advancements in volumetric imaging makes it possible to generate high-resolution three-dimensional reconstructions of bones in throughout the foot and ankle. The use of weightbearing computed tomography allows for the analysis of joint relationships in a consistent natural position that can be used for statistical shape modeling. Using statistical shape modeling, a population-based statistical model is created that can be used to compare mean bone shape morphology and identify anatomical modes of variation. A review is presented to highlight the current work using statistical shape modeling in the foot and ankle with a future view of the impact on clinical care.

Biomechanical Sequelae of Syndesmosis Injury and Repair 77

Jennifer A. Nichols, Chloe Baratta, and Christopher W. Reb

This review characterizes fibula mechanics in the context of syndesmosis injury and repair. Through detailed understanding of fibula kinematics (the study of motion) and kinetics (the study of forces that cause motion), the full complexity of fibula motion can be appreciated. Although the magnitudes of fibula rotation and translation are inherently small, even slight alterations of fibula position or movement can substantially impact force propagation through the ankle and hindfoot joints. Accordingly, implications for clinical care are discussed.

Reflections on Presurgical and Postsurgical Gait Mechanics After 50 Years of Total Ankle Arthroplasty and Perspectives on the Next Decade of Advancement 99

Robin M. Queen and Daniel Schmitt

Video content accompanies this article at http://www.foot.theclinics.com.

Although not the most prevalent form of lower limb pathology, ankle arthritis is one of the most painful and life-limiting forms of arthritis. Developing from overuse and various traumatic injuries, the effect of ankle arthritis on gait mechanics and effective treatment options for ankle arthritis remain an area of extensive inquiry. Although nonsurgical options are common (physical therapy, limited weight-bearing, and steroidal

injections), surgical options are popular with patients. Fusion remains a common approach to stabilize the joint and relieve pain. However, starting in the early 1970s, total ankle arthroplasty was proposed as an alternative to fusion.

Definitions and Measurements of Hindfoot Alignment and Their Biomechanical and Clinical Implications 115

Sorin Siegler, Luigi Piarulli, and Jordan Stolle

This article presents a critical review of the past and the current state of the art in defining and measuring hindfoot, ankle, and subtalar alignment. It describes the transition occurring at present from two-dimensional to three-dimensional (3D) alignment measurements, which accompany the emergence of new, functional, high-resolution imaging modalities such as the weight-bearing cone-beam computerized tomography (CT) imaging. To ease and enhance the transition and acceptability of 3D alignment measurements, new acceptable standards for different clinical application are highly desirable.

Current Challenges in Chronic Ankle Instability: Review and Perspective 129

Matthieu Lalevée, Donald D. Anderson, and Jason M. Wilken

Chronic ankle instability (CAI) is common, disabling, and represents a significant socioeconomic burden. Current treatment options are not adequately efficacious. CAI is multifaceted, yet it is commonly addressed in terms of either mechanical instability or functional impairment. Both are inherently linked. Basic research must be conducted to foster reliable translational research encompassing both mechanical and functional aspects. A review was conducted to identify CAI risk factors for inclusion in future studies, and we offer here opinions and perspectives for future research.

Effect of Braces on Performance in the Context of Chronic Ankle Instability 145

Claire E. Hiller and Paula R. Beckenkamp

Ankle braces are commonly recommended for prevention of ankle sprains, especially secondary sprains, rehabilitation, and return to normal activity or sport after injury. One common resistance to use is the feeling that braces will impede functional performance. For people with chronic ankle instability, the limited research indicates that the use of semirigid, lace-up, or soft-shell braces will not affect, and in some cases, may enhance performance. Activities that could be enhanced are jumping, hopping, and dynamic balance.

Disease-Specific Finite element Analysis of the Foot and Ankle 155

Hamed Malakoutikhah and Leonard Daniel Latt

Finite-element analysis is a computational modeling technique that can be used to quantify parameters that are difficult or impossible to measure externally in a geometrically complex structure such as the foot and ankle. It has been used to improve our understanding of pathomechanics and to evaluate proposed treatments for several disorders, including progressive

collapsing foot deformity, ankle arthritis, syndesmotic injury, ankle fracture, plantar fasciitis, diabetic foot ulceration, hallux valgus, and lesser toe deformities. Parameters calculated from finite element models have been widely used to make predictions about their biomechanical correlates.

Thermal Injuries Occurring to the Foot: A Review **173**

John M. Tarazi and Adam D. Bitterman

Thermal injuries are one of the most common injuries in both civilian and combat scenarios. The importance of clinical determination of burn and frostbite injuries and treatment involves understanding the pathophysiology and mechanisms of these injuries while continually reviewing literature and studying new treatment modalities. This present review examines the (1) epidemiology, (2) etiology, (3) pathophysiology and classification, and (4) treatment of thermal injuries occurring to the foot. In addition to the paucity of new literature and studies on thermal injury, this is the first review, to the best of our knowledge, to examine the management of thermal injuries occurring to the foot.