CORR Insights®: Are Abnormal Muscle Biomechanics and Patient-reported Outcomes Associated in Patients With Hip Dysplasia?

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Where Are We Now?

Mechanical factors play an important role in the etiology of osteoarthritis [5], and some variations in bony anatomy—in particular dysplasia of the hip (DDH)—are known to increase the risk of hip osteoarthritis (OA) [9, 10]. Although variation in bony anatomy has received considerable attention [3, 6], most likely because it is readily visible on imaging, less is known about the impact that variations in muscle biomechanics may have on this problem. Variations in bone anatomy will give rise to variations in moment arms and muscle forces. Because of the practical limitations to directly measuring muscle forces, these usually are derived from a combination of motion analysis, imaging, and musculoskeletal modeling [11]. This requires considerable investigative infrastructure, background knowledge, and funding. The redundant (number of quantities to be determined exceeding the number of available equations) nature of the musculoskeletal system increases the complexity of musculoskeletal modeling [8]. The challenges of estimating muscle forces have limited the number of studies performed as well as the number of individuals evaluated. Because muscle forces are the main contributors to joint reaction forces, it is clearly important to understand the consequences of bony abnormalities such as DDH on muscle forces and the subsequent influence on physiologic function and quality of life.

In the current issue of *Clinical Orthopaedic and Related Research*®, Wu et al. [14] investigated, for the first time to my knowledge, the relationship between muscle-induced biomechanics and patient-reported outcome measures (PROMs) for patients with DDH and control participants. The muscle-related biomechanics of patients with DDH were associated with worse function and pain outcomes as measured by widely used PROM instruments. The University of California Los Angeles activity score did not have associations with biomechanical variables. DDH is

commonly diagnosed based on radiographically observed bony abnormalities, but it does not always lead to hip OA, presenting a difficulty in the treatment of this population. From my point of view the most interesting finding of Wu et al is that a group of individuals with DDH exhibited muscle induced biomechanical variables with a relatively large range of values across the cohort, considerably larger range than for the control group, and these variables were correlated with PROMs. The association of biomechanical variables with pain and function allows us to better predict prognosis in patients who have bony abnormalities from DDH than is possible from the bony anatomy alone.

Where Do We Need To Go?

As stated above, estimating biomechanical variables is complex and involved, creating practical limits on study participant numbers. Wu et al. [14] evaluated 20 patients with DDH and 15 controls, and all were female. It is important to increase the number of individuals and include male patients to establish whether the findings are generally applicable. The pioneering work of Delp et al. [4] in providing the OpenSim software for musculoskeletal modeling has made the technique more widely available. The current state of the art, however, still requires motion analysis facilities and, critically, specialist-level technical knowledge. Two areas of opportunity therefore become immediately obvious. First, increasing the number of patients evaluated combined with surveillance to record the development of hip OA will be able to provide evidence about whether biomechanical factors, considered in conjunction with bony abnormalities, can predict the risk of hip OA. And, second, finding a reliable, more easily obtained surrogate measure for biomechanical variables will help incorporate the assessment of

muscle-related biomechanics into routine clinical practice.

How Do We Get There?

Repeating the measurements and performing the modeling described by Wu et al. [14] on a considerably larger and more representative cohort is needed to further explore the clinical use of the authors' findings. Collecting data from motion studies is complex, and although specialist centers can routinely do this, subsequently undertaking the musculoskeletal modeling introduces further challenges. MRI is needed to personalize the model parameters to each individual, and the sensitivity of biomechanical outcomes to variation in gait data collection protocols needs to be minimized. Aligned with the conclusions of Uhlrich et al. [13], there is an opportunity for a large-scale collaborative project between bioengineering research groups (with motion capture and musculoskeletal modeling expertise and facilities) and orthopaedic surgeons with a specialist interest in DDH who have reasonably large numbers of appropriate patients. Establishing clear measurement protocols should be straightforward, and the advent of affordable, secure cloud storage will facilitate data curation. The curation of data remains a fundamental challenge, and the effort required to make data useful outside the setting in which it was obtained is often underappreciated. Performing large-scale clinical studies has become established in orthopaedic surgery; however, this is still relatively rare in the biomechanics community. The number of widely available, curated motion analysis datasets is low; however, the ones that are available have had immense utility for musculoskeletal research. Examples of widely used data are those from Bergmann et al. [1, 2] and Taylor et al. [12]. Fregly et al. [7] introduced the concept of the Grand Challenge, making motion analysis datasets available to the modeling community. A Grand Challenge set around the theme of measuring and sharing biomechanical and clinical data in patients with DDH could be a useful approach.

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