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CORR Insights®: Subject-specific Patterns of Femur-labrum Contact are Complex and Vary in Asymptomatic Hips and Hips With Femoroacetabular Impingement

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Where Are We Now?

Treatment approaches for femoroacetabular impingement (FAI) are rapidly evolving and remain diverse [2, 11]. The large discrepancy in treatment options likely stems from the broad diagnosis of FAI, the lack of clear understanding between morphology and dynamic injury mechanisms, and the lack of quality long-term outcome studies to support the use of one treatment option

above another for particular presentations of FAI [2, 7, 10].

Orthopaedists commonly define and diagnose FAI based on radiographic images and passive clinical range of motion testing, two methods that are likely too simplistic to understand the subject-specific three-dimensional (3-D) and dynamic nature of the interaction between bone morphology and soft tissue damage in an FAI hip. As a result, Orthopaedists commonly utilize more sophisticated imaging technolo-

gies such as MRI and CT to diagnose and plan surgical treatments, but these imaging modalities are static by nature and do not allow for a direct visualization of the injury mechanism. Many studies have attempted to better understand how sometimes subtle morphologic differences can lead to the eventual painful injury associated with FAI, but each is with their weaknesses. Motion-capture methods have been utilized to understand the dynamic presentation of FAI during common activities of daily living, and to assess surgical treatment of the condition quantitatively [5, 8]. However, motion-capture alone cannot directly visualize the interactions of the internal structures. Computer modeling based on 3-D bone geometry has been used to better understand reduced ROM and potential locations of impingement [1, 9], but these models do not include soft tissues. Additionally, outcome studies for FAI treatment generally include small numbers of patients and present short-term followup results [3, 10].

This CORR Insights® is a commentary on the article “Subject-specific Patterns of Femur-labrum Contact are Complex and Vary in Asymptomatic Hips and Hips With Femoroacetabular Impingement” by Kapron and colleagues available at: DOI: [10.1007/s11999-014-3919-9](https://doi.org/10.1007/s11999-014-3919-9).

The author certifies that he, or any member of his immediate family, has no funding or commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

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This *CORR Insights®* comment refers to the article available at DOI: [10.1007/s11999-014-3919-9](https://doi.org/10.1007/s11999-014-3919-9).

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Where Do We Need To Go?

The model-based tracking method presented by Kapron and colleagues represents a relevant and necessary step forward in the process of better understanding the dynamic characteristics of FAI [4]. Three-dimensional surfaces for the pelvis, femur, and labrum were generated from a CT arthrogram and fit to dynamic dual-plane fluoroscopy images during a clinical ROM exam. The labrum was assumed to be rigidly attached to the acetabulum. The study determined that it is difficult to predict the location of injury based on measured bone-to-bone distance alone and that patterns of contact were highly patient-specific. Adding the labrum into the model allowed for better prediction of the intraoperative observed injury location. This study proposes an advanced method to visualize the internal structures of the hip during movement. The findings of this study highlight the need to understand how subtle differences in intersubject 3-D hip morphology can alter the injury mechanics and therefore alter the extent and location of needed surgical intervention. The model proposed by Kapron and colleagues is more advanced than what would be considered common clinical practice, but it has not been applied to loaded dynamic motions of daily living and has not been validated for use

in surgical planning or predicting long-term outcome. Loaded movements indicative of a person's daily activities should be used to assess the outcome of surgical intervention since the intended purpose of treatment is to restore function to the joint and to prevent further injury. Large, prospective, long-term outcome studies that utilize 3-D models to visualize hip morphology pre and postoperatively are needed to validate the use of surgical intervention for the treatment of FAI.

How Do We Get There?

Improvements in treating FAI and preventing long-term consequences such as the reformation of the injury-inducing morphology or the development of hip osteoarthritis will only come with a greater understanding of the subject-specific injury mechanisms. Many studies have strived to understand the static 3-D geometry of the hard and soft tissues, the 3-D movement of the bone during ROM, and the active and passive kinematics in an FAI hip joint [1, 3–6, 8, 9]. However, studies need to incorporate each of these elements for a large group of diverse FAI patient subtypes. For example, a study that develops 3-D models of both the hard and soft tissues in a FAI hip or uses functional

MRI technology to actually observe the hip would greatly improve our understanding of the subtle interplay between the bone morphology and the soft tissue damage. Patient-specific models could provide doctors with the ability to determine how much bone should be removed in order to eliminate the injury mechanism and restore normal function to the hip. Additionally, well designed, prospective long-term studies need to be performed to evaluate the various surgical interventions and to better understand which patients redevelop abnormal bone morphology and/or osteoarthritis. Societies such as the Orthopaedic Research Society® and the American Academy of Orthopaedic Surgeons should provide monetary and infrastructure resources as incentives for universities and hospitals/clinics around the country to join together for a larger prospective study. Because of the often subtle nature of the morphologic differences in FAI patients, only a larger study involving multiple centers will have sufficient power to predict treatment outcome.

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