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CORR Insights®: The Impingement-free, Prosthesis-specific, and Anatomy-adjusted Combined Target Zone for Component Positioning in THA Depends on Design and Implantation Parameters of both Components

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Where Are We Now?

Although dislocation continues to be a problem after THA, we have made progress in decreasing dislocation rates. Historical rates of dislocation after primary THA were around 3% [8, 12], but the most-recent Australian registry report indicates that among primary THAs performed for osteoarthritis since 2006, the cumulative 10-year risk of revision for dislocation was only 0.8% [2]. Improved surgical technique, introduction of modularity and offset stem options, and utilization of larger femoral heads have contributed to reducing dislocation after primary THA.

A surgeon-controlled factor that contributes to dislocation is implant position. For decades, the Lewinnek "safe zone" [8] guided THA acetabular component positioning, but it has not proven to correlate well with dislocation [1]. Current research on the relationship of acetabular component position with dislocation largely focuses on movement and position of the pelvis, and effects on functional acetabular component position [3, 4, 6]. In the current study, Widmer [11] takes a different and complementary approach. The author expands on the concepts of Lewinnek by simultaneously considering the contributions of cup anteversion and inclination, and femoral component anteversion, neck shaft angle, and head size on prosthetic to prosthetic impingement. This detailed analysis quantitatively demonstrates how this expanded number of surgeon-controlled factors affects impingement-free hip ROM.

Interestingly, in most circumstances, this new "safe zone" is smaller than the original as described by Lewinnek [8]. It is useful to note that, at least for a pelvis that is oriented with the anterior pelvic plane in the vertical position, the "safe zone" free of prosthetic-to-prosthetic impingement is maximized when the neck-shaft angle is 125° to 127°, stem anteversion is 10° to 20°, and radiographic cup anteversion is 17° to 25°.

Where Do We Need To Go?

The information presented in the current study needs to be integrated with the emerging data on pelvic motion and functional acetabular position [3, 4, 6]. The safe zones described in this paper are not patient-specific and assume a static anterior pelvic plane. In order to assess the risk of prosthetic-prosthetic impingement, it is unrealistic to assume that the pelvis remains in a fixed position during normal activities such as sitting and standing.

This CORR Insights® *is a commentary on the article* "The Impingement-free, Prosthesis-specific, and Anatomy-adjusted Combined Target Zone for Component Positioning in THA Depends on Design and Implantation Parameters of both Components" *by Widmer available at:* DOI: 10.1097/CORR.0000000000001233.

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Furthermore, the current analysis focuses exclusively on prosthetic-prosthetic impingement, which is important, but is not the only source of impingement for the prosthetic hip. My personal experience is that posterior hip instability is more commonly caused by extraarticular bone-bone or bone-soft tissue-bone impingement. Extraarticular impingement is a much more difficult problem to address with mathematical models because patient bony and soft tissue anatomy is variable and challenging to model accurately. Solving prosthetic-prosthetic impingement is an important first step, but it is only the beginning.

Finally, it is very important to consider whether it is possible to apply this information in the operating room, and if so, whether it is worth the time and expense to do so. As the "safe zone" proposed in this article is even smaller than the one proposed by Lewennek, expensive advanced technology may be required to reliably hit the target positions determined by the computer model. Prior studies on navigated hip arthroplasty have shown that the target implant position can be hit more reliably using computer assistance, but these added complexities and expenses have not yet proven to impact dislocations or revisions, which are really the outcomes we care about [5, 10].

How Do We Get There?

To address the issue of pelvic motion, computer models such as the ones presented in this study will need to be further developed to incorporate additional parameters such as pelvic incidence and pelvic motion in at least the sitting and standing positions. This will allow the models to be more patient-specific and thus more predictive of prosthesis-prosthesis impingement in a dynamic real-world setting.

I believe that ultimately to make a more substantial impact on dislocation risk, however, it will be necessary to account for extraarticular impingement, a much more challenging endeavor.

To address this, mathematical modeling will need to be even more complex and more patient specific. Indeed, at least one model to address bone-bone impingement following total hip arthroplasty has been published in the bioengineering literature [9]. To apply such a model in clinical practice, individual patient anatomy will be required as input, likely from preoperative three-dimensional imaging such as computed tomography. Assessing risk of bone-soft tissue-bone impingement will be even more difficult to model as it will likely require making assumptions regarding how close one can get to bone-bone impingement before interposed soft tissues block further motion.

When considering this potential line of technological development to address dislocation following THA, however, it is important to step back and remember that dislocation is multifactorial in etiology. It still remains to be determined whether "perfect" patient-specific total hip arthroplasty component positioning (however it is defined and attained) will substantially reduce dislocation rates. Do muscle weakness, soft tissue tension, patient compliance, cognitive dysfunction or other factors not related to implant position currently influence dislocation rates more than implant position? Will it be worth the cost of preoperative multi-position three-dimensional imaging, customized computer analysis, and intraoperative navigation or robotic assistance to further reduce dislocation rates? With the current 10-year rate of revision for dislocation following primary THA being 0.8% [2], is it even possible to reduce dislocation rates low enough to justify the cost of incorporating this expensive preoperative analysis and intraoperative technology to the nearly 400,000 primary THA surgeries performed annually in the United States [7]? An analysis weighing the financial burden of dislocation against an estimate of the possible reduction in dislocation rate with "perfect" implant position and an estimate of the cost of the technology required to achieve such "perfect" position would be needed to address these important questions.

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