The Journal of Arthroplasty 31 (2016) S264–S268

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Basic Science

Acetabular Cup Anteversion and Inclination in Hip Range of Motion to Impingement

Thomas F. McCarthy, BS, MBA [a], Vincent Alipit, BS [a], Jim Nevelos, PhD [a], Randa K. Elmallah, MD [b], Michael A. Mont, MD [b,*]

[a] Stryker Orthopaedics, Mahwah, New Jersey
[b] Rubin Institute for Advanced Orthopedics, Center for Joint Preservation and Replacement, Sinai Hospital of Baltimore, Baltimore, Maryland

ARTICLE INFO

Article history:
Received 1 December 2015
Received in revised form
20 January 2016
Accepted 26 January 2016
Available online 17 March 2016

Keywords:
safe zone
total hip arthroplasty
acetabular cup
inclination
anteversion
impingement

ABSTRACT

Background: It is advocated that to avoid complications associated with femoral stem impingement, acetabular positioning should be within a "safe zone." However, instability remains prevalent despite accurate cup positioning, with studies showing dislocations of cups despite positioning within safe zones. We assessed cup position angles associated with impingement in a group of subjects during (1) squatting; (2) object pick-up; and (3) low chair rise.
Methods: Ten subjects (mean age, 69 years; body mass index, 28.4 kg/m^2) performed object pick up, squatting, and low-chair rising. Femur-to-pelvis relative motions were recorded for flexion/extension, abduction/adduction, and internal/external rotation. A previously reported custom-validated hip range-of-motion 3-dimensional simulator was used, set for neutral pelvic tilt and 15° of stem version. Acetabular cup abduction and anteversion combinations were chosen. The software computed minimum clearances between components for any hip position. An idealized tapered wedge stem with a 132° neck angle and a 36-mm femoral head was used.
Results: Eight subjects had impingement on squatting between 21° and 51° of inclination. During object pick-up, 9 subjects had impingement with inclination and anteversion angles within the "safe zone." In low-chair rise, 8 subjects had impingement at cup inclination angles between 14.5° and 49.5°.
Conclusion: The true acetabular target for impingement-avoidance motion is much smaller than previously believed and varies considerably between patients. Certain activities, such as picking up an object, low-chair rise, and squatting reduce the size of the safe zone. This study supports the need for better individualized preoperative patient-specific planning and intraoperative execution for placement of the components.

Component impingement after total hip arthroplasty (THA) can be associated with damage to the acetabular liner, polyethylene wear, and subsequent dislocation [1,2]. The causes of impingement are multifactorial, but they may be associated with activities that have a high degree of motion, the geometry of the implants, pelvis, and femur, and the position of the implants, specifically stem and cup version and inclination.

It is commonly advocated that accurate component positioning is integral to avoid these complications, and the use of "safe zones," such as that described by Lewinnek et al [3], have been used to guide acetabular cup placement. With this method, the acetabular cup is placed using the anterior pelvic plane as a reference, defined by the pubic symphysis and anterior superior iliac spines. However, despite the implementation of a "safe zone," the incidence of impingement and subsequent dislocation after THA remains inexplicably high, with some reports demonstrating that up to 70% of dislocated hips had cups placed within Lewinnek's safe zone of anteversion [4].

The use of predefined parameters may be deemed simplistic, particularly as it does not account for patient-specific anatomic variations. Given the prevalence of dislocations, our purpose was to assess the range of motion to and the cup position angles associated with impingement in individual patients. Specifically, we assessed

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.arth.2016.01.067.

* Reprint requests: Michael A. Mont, MD, Rubin Institute for Advanced Orthopedics, Center for Joint Preservation and Replacement, Sinai Hospital of Baltimore, 2401 West Belvedere Avenue, Baltimore, MD 21215.

http://dx.doi.org/10.1016/j.arth.2016.01.067
0883-5403/

the cup inclination and anteversion angles that are associated with impingement with extreme motions such as: (1) squatting; (2) object pick-up; and (3) low chair rise.

Methods

Ten subjects were selected who had a mean age of 69 years (range, 60-83 years) and a mean body mass index of 28.4 kg/m^2 (range, 24.9-37.8 kg/m^2). They were asked to perform 3 "extreme" motions that can potentially lead to posterior hip dislocation: low-chair rising, squatting, and picking up an object. To demonstrate the motion of picking up an object, the subjects bent forward at the hips and knees and retrieved an object from the floor, from a standing position. Using motion trackers that were affixed to the subjects at the anterior superior iliac spine and sacrum, femur-to-pelvis relative motions were recorded throughout for flexion/extension, abduction/adduction, and internal/external rotation.

A previously reported custom-validated hip ROM 3-dimensional simulator was used [5]. The user imports implant models and sets parameters for pelvic tilt, stem version, and specific motions as defined by the subjects. The model was validated using simulations with a computer-aided design and drafting software, where areas of impingement on the ROM tool output corresponded with a matching impingement area on the computer-aided design and drafting software (see Figs. 1 and 2). Although the model can take into account bony impingement for bone-on-bone and component-on-bone, this was not considered in the present analysis.

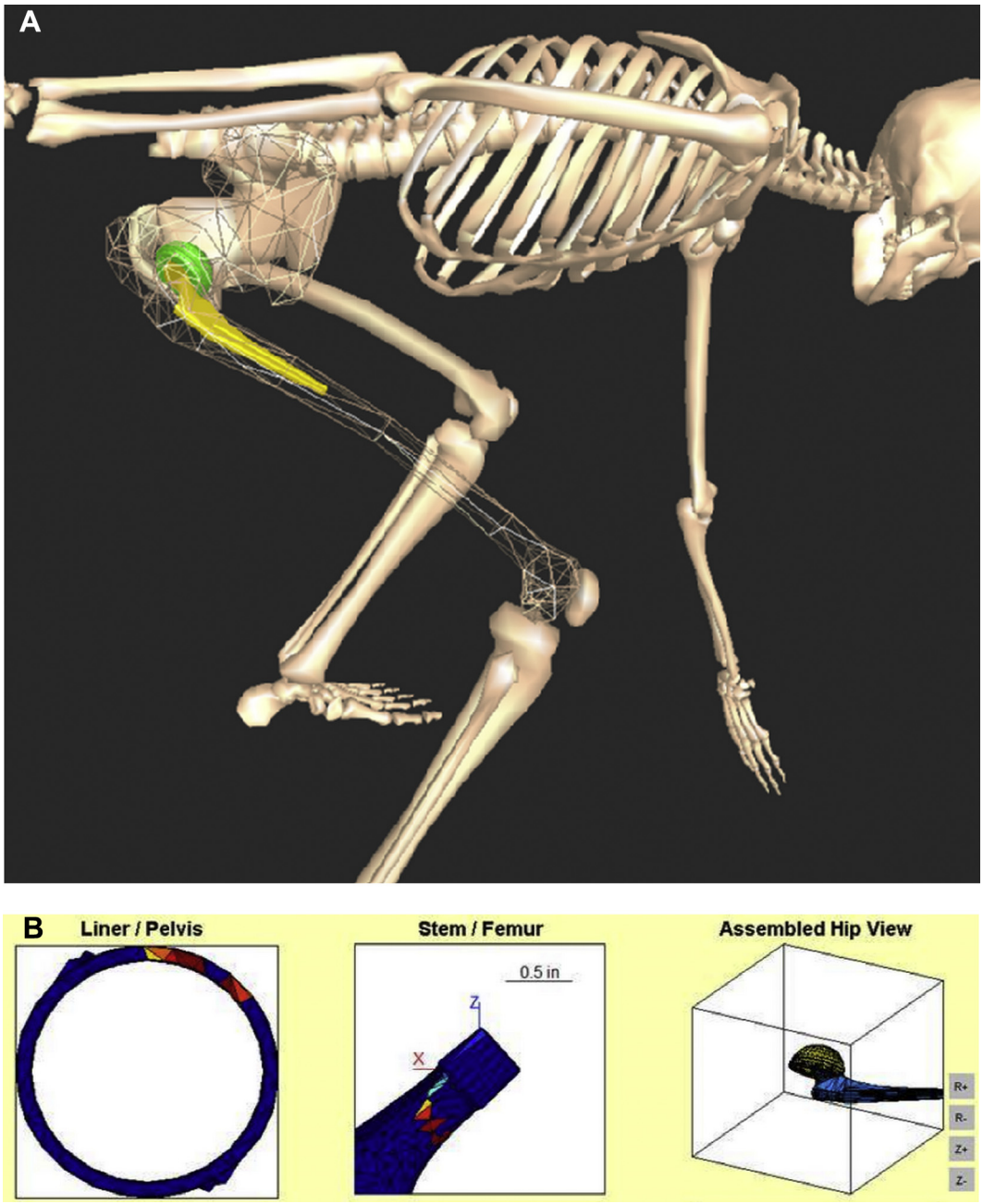

Fig. 1. (A) The area of impingement as demonstrated on the CAD model. (B) The same impingement zone correlated with the ROM tool. CAD, computer-aided design and drafting; ROM, range of motion.