Assessment of Total Hip Prostheses Impingement in a Pivot Model

Kevin Abbruzzese[1], Ilya Borukhov[1], Michael Barkachy[1], Jarett Michaelson[1], Sally LiArno[1]
[1]Stryker, Mahwah, NJ, USA

Disclosures: K. Abbruzzese: 3A; Paid Employee of Stryker. 4; Stock or Stock Options. I.Borukhov: 3A; Paid Employee of Stryker; Stock or Stock Options. M. Barkachy: 3A; Paid Employee of Stryker; Stock or Stock Options. J. Michaelson: 3A; Paid Employee of Stryker; Stock or Stock Options. S. LiArno: 3A; Paid Employee of Stryker; Stock or Stock Options.

Introduction: Impingement is a significant complication following total hip arthroplasty (THA), often resulting from metal-on-metal contact between prosthetic components. Mechanical testing of THA components is a preliminary means to evaluate these risk factors. The ASTM F2582-20 standard outlines a method for evaluating impingement in femoral and acetabular prosthesis designs under laboratory conditions. However, specific sections within the standard acknowledge limitations that underscore the need for clinically relevant testing. A posterior hip impingement model using a pivot activity was developed for the AMTI VIVO where THA components were assessed in a clinically relevant activity designed to induce impingement.

Methods: The stability and impingement resistance of fixed bearing THA inserts were evaluated under clinically relevant conditions that mimic real-life pivoting kinematics associated with posterior impingement during a pivot task, adapted from Nadzadi et al [1]. This assessment examined kinematic evaluations using the AMTI VIVO with worst-case orientation parameters, including 55° cup inclination, 35° cup anteversion, and 10° stem version [2,3]. Test duration included 100,000-cycles to replicate the repetitive strain experienced in daily activities for THA patients with osteoarthritis [4]. Three quadrants of a fixed bearing THA insert were assessed in the pivot model submerged in a deionized water bath where the 2D cross sectional wear damage was measured with calipers and recorded after test completion. The length and width of the primary wear scar on the liner and stem was documented and the damage areas were estimated as an ellipsoid.

Results: The fixed bearing THA sample underwent pivot testing where the liner and stem wear scars were measured, Table 1. The pivot testing resulted in multiple contact points with two wear scars accumulating on both the liner and stem, Figure 1. The average length, width, and area of the primary impingement wear scar on the raised rim for all samples was 9.19mm ± 0.73mm, 3.26mm±0.23, and 23.64 mm²±3.60 mm², respectively. The average length, width, and area of the primary impingement wear scar on the stem for all samples reported averages of 8.76mm ± 0.39mm, 3.10mm±0.04, and 21.34 mm²±1.01, respectively.

Discussion: The pivot test evaluated THA components in a worst-case orientation with clinically relevant kinetic and kinematic conditions. The test method offers a meaningful alternative to ASTM F2582 to evaluate relevant forms of posterior impingement damage and characterize wear scars for both liner and stem which can be compared to retrieval damage. This clinically relevant testing approach deepens our understanding of metal-on-metal impingement from functional activities and supports a greater understanding of THA component placement and the resulting performance during an activity of daily living.

Significance/Clinical Relevance: The purpose is to evaluate the stability and impingement resistance of total hip arthroplasty (THA) implants under clinically relevant conditions that mimic real-life pivoting maneuvers associated with posterior impingement. The pivot method serves as an alternative to ASTM F2582 that improves upon the standardized laboratory waveforms incorporating mal-positioned component position designed to induce impingement contact under clinically measured kinematics and kinetics.

Table 1. Two-dimensional damage measures from pivot activity per fixed bearing THA sample

	Liner			Stem		
	Length (mm)	Width (mm)	Area(mm²)	Length (mm)	Width (mm)	Area(mm²)
Sample-T0	10.02	3.53	27.78	9.20	3.10	22.40
Sample-T1	8.65	3.12	21.20	8.61	3.14	21.23
Sample-T2	8.90	3.14	21.95	8.46	3.07	20.40
Average	**9.19**	**3.26**	**23.64**	**8.76**	**3.10**	**21.34**
Std	**0.73**	**0.23**	**3.60**	**0.39**	**0.04**	**1.01**

Figure 1. Damage area for fixed bearing liner (*left*) and stems (*right*) during pivot activity