Published and presented at the 65th annual meeting of the American Academy of Orthopaedic Surgeons, new Orleans, LA

TOTAL KNEE SYSTEM PERFORMANCE MEASUREMENT THROUGH COMPUTERIZED INTRINSIC STABILITY TESTING

S. McGuan*, Dr. Murali Jasty, Michael Kaufman
* Mechanical Dynamics, Inc., Ann Arbor, MI 48105, Wright Medical Technologies, Arlington TN 38002

INTRODUCTION: Restoration of normal knee joint function through surgical reconstruction is dependent upon load sharing between the implant, surrounding ligaments and other supporting soft tissue structures. Excision, surgical release and progressive pathological weakening of ligamentous structures results in an increased dependency upon the implant system for stability. The intrinsic stability conferred by the total knee system may be evaluated by emulating displacement-based experimental testing with computer simulation. Specific tests such as the Greenwald[1] stability test may be performed or any variance of a displacement-based experiment providing anteroposterior, mediolateral and rotary force v. displacement data. These data provide a basis for comparison of stability performance for designs *before* physical prototypes are developed. This study presents a test bed for parametric TKR variational analyses that features a novel surface-to-surface contact algorithm for solving joint dynamics.

Figure 1 Intrinsic Stability Simulation

METHODS: A computer software system (Virtual/KNEE, Mechanical Dynamics, Ann Arbor, MI, USA) is utilized to assess the intrinsic performance characteristics TKR systems. During the simulation, the software generates contact forces based on a network of compressive springs at discrete data points on a surface and is accessed in reaction to the forces applied to the system. Changing topologies are foreseen through the incorporation of stick/slip friction and local deformation. Resolution of the non-linear (differential/algebraic) equations yields the stability values that refer to the knee components' displacement, while guided by their inherent geometrical features. Using this method, software automates the complete experimental test protocol including component neutral position determination and loading. The loading set for anterior, posterior, medial, lateral and rotational stability was chosen to be consistent with those reported during normal gait [2,3,4]. (Table 1) The respective shearing displacement were then applied to the system at a loading rate of 5.0 inches/ min until implant subluxation.

RESULTS: The ADVANCE® PCL Sparing Knee System (Wright Medical Technology, Arlington, TN USA) was mounted in a Model 1115 Instron testing machine and tested with a medial pivot tibial insert and a semi-congruent tibial insert using the loading protocol listed above. The test was also performed using the CAD models of the geometric surfaces in the software system. A comparison of the results of the test are listed in table 2.

CONCLUSIONS: Simulation outcome agrees considerably with experimental results. Immediately, this approach may have a tremendous impact on decreasing product design cycle.

Table 1 - Load Set for Intrinsic Stability Test

Direction of Tibial Disp.	Flex Ang	Comp Joint Force	Physiologic Constraint	% Gait Cycle
Anterior	0°	2.3 * BW	1.00 * BW	5% walking
Posterior	0° 90°	4.0 * BW 2.4 * BW	2.00* BW 270 lbf	50%walking, Chair rise
Medial	30°	4.0 * BW	.75 * BW	15% walking
Lateral	0°	4.0 * BW	1.00 * BW	50% walking

Table 2 - Simulation Results Compared to Experiment

Tib. Motion Flex Angle	**Sim** Sublux Load *Med-Pivot Insert*	**Exp** Sublux Load *Med-Pivot Insert*	**Sim** Sublux Load *Semi_Con Insert*	**Exp** Sublux load *Semi_Con Insert*
Ant. @ 0° Flex	149 lbs	145 lbs	127 lbs	140 lbs
Post. @ 0° Flex	566 lbs	416 lbs	488 lbs	336 lbs
Post. @ 90° Flex	428 lbs	319 lbs	290 lbs	233 lbs
Med. @ 30° Flex	358 lbs	281 lbs	435 lbs	300 lbs
Lat. @ 0° Flex	362 lbs	231 lbs	411 lbs	303 lbs
5° Ext. Rot @ 7.5° Flex	85 in-lbs		68 in-lbs	

REFERENCES:

1. Postak, P., et al, A., AAOS, 1991.
2. Morrison, J.B.: Journal of Biomechanics, , 1970.
3. Morrison, J.B.: Bio-Medical Engineering, , 1969.
4. Seireg, A., et al.: Journal of Biomechanics, 1975.