Change in Load Sharing Characteristics due to Varus Knee Deformity in Degenerative Osteoarthritis Knee Joint

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INTRODUCTION

Degenerative osteoarthritis (OA) of the knee joint is a progressive disease of cartilage degradation. It causes abnormal load transmittion with tibia-femoral pain and may progress to varus leg deformity with accelerated degeneration at the medial side[1]. Previous biomechanical finite element(FE) studies were done to elucidate the mechanism of OA in terms of load transmission and degeneration. However, their FE models were largely limited to normal alignment of the knee joint leaving out varus deformity of the patient. In this study, we constructed a degenerative knee model with varus deformity to investigate the load transmisssion charactersitics.

METHODS

A 3D FE model for a normal knee joint was constructed from CT scan data(a normal male, 27 years of age, 70kg) by using MSC/Patran 2008(MSC software Corp., USA). 2D truss elements were chosen to represent ligamentous and tendinous tissues. Menisci were constructed with 3D volume elements and 2D truss elements which have incompressible and nonlinear elastic material characteristics[1]. This model was validated by comparing its range of motion and contact force at the menisci with those in literature[2]. Based on this model, 3 cases of degenerative OA model were constructed by varying the material properties of articular cartilages and varus deformity of the knee joint (Table 1)[3-5]. The normal alignment angle of knee joint was defined as the angle between a line from the center of the femoral head to the center of the joint, and a line from the center of the joint to the ankle talus (Fig. 1-d) [3]. Angles of the knee joint alignment were varied from normal value of 188° (OA-N, Fig 1-a) to simulate moderate (180° OA-D1, Fig 1-b), and severe (172° OA-D2, Fig 1-c) varus deformity cases. Severity was based on value found in the literature for Korean OA patents[3]. Multi-step loading and boundary conditions (0~60% gait cycle) were applied to simulate normal gait[2]. Changes in load sharing characteristics of the tibio-femoral joint were predicted by using ABAQUS/Explicit v6.7 (Simulia Corp., USA).

Table 1. Conditions of FE models

Condition		Varus deformity angle[3] (Deg)	Material property of articular cartilage[4]		Friction coefficient of tibio-femoral interface[5]
			E	υ	
Normal		188	12 MPa	0.45	0.001
OA	N	180	3 MPa (medial) Early-Stage OA	0.33	0.1
	D1				
	D2	172			

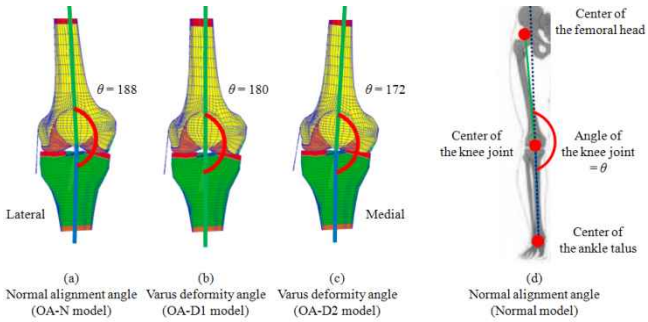

Fig. 1. Angle of the knee joint alignment

RESULTS AND DISCUSSION

Our results indicated that the higher the varus deformity was the more medially concentrated loading was seen regardless of the knee joint orientation in a gait cycle (Fig 2). This confirms the viscious cycle of accelerating medial cartridge damages arising from malalignement of the OA knee as found in clinical cases. Particularly, the differences of load sharing characterisitics between the medial and lateral were most promient during the single stance position when the body weight was being supported by a single leg. This may help to understand the finding in a clinical study[3] where OA patients tended to walk in shorter stride. It is very likely that the patients have exhibited a gait pattern to lessen the knee pain probably arising from high losingle stance period .

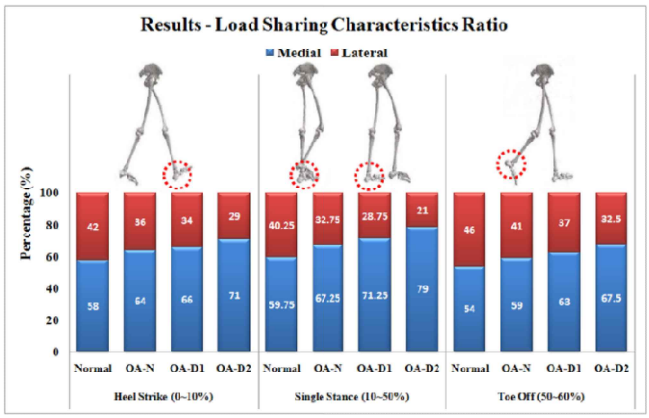

Fig. 2. Results of load sharing characteristics between the medial and lateral sides of the tibia

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