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Short communication

Effect of acetabular component anteversion on dislocation mechanisms in total hip arthroplasty

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ABSTRACT

Quantifying soft-tissue tension around the hip joint during total hip arthroplasty remains difficult. In this study, a three-dimensional computer-aided design model was developed to clarify how component position in total hip arthroplasty contributes to the primary cause of posterior dislocation in cases of flexion, adduction and internal rotation. To better understand the influences of anteversion angle of the acetabular component, its effects on the primary causes of dislocations and the range of motion were investigated. Three different primary dislocation mechanisms were noted: impingement of the prosthetic femoral neck on the cup liner; impingement of the osseous femur on the osseous pelvis; and spontaneous dislocation caused by soft-tissue traction without impingement. Spontaneous dislocation could be detected by calculating hip forces at any thigh position using the computer-aided design model developed. In computer analysis, a transition from prosthetic impingement rate to osseous impingement rate occurred with increasing anteversion angle of the acetabular component. Spontaneous dislocation was detected at angles $>10^\circ$ of anteversion of the acetabular component when flexion occurred with extreme adduction and internal rotation. This study demonstrated the possibility of spontaneous dislocation that results not from prosthetic or bony impingement but from muscle traction with increased range of motion.

1. Introduction

Dislocation remains a common complication of total hip arthroplasty (THA). Many factors affect the prevalence of dislocations after THA, including soft-tissue laxity, surgical approach, component design and position and patient factors (Barrack, 2003; Burroughs et al., 2005; D'Lima et al., 2001; Soong et al., 2004; Tanino et al., 2007). The possibility of dislocation without impingement has previously been discussed (Pedersen et al., 2005). Bartz et al. (2000) investigated dislocation mechanisms using in vitro cadaver simulations with load cables to simulate muscle tractions and they reported spontaneous dislocation occurring without impingement. Similarly, an in vivo intraoperative study suggested that soft-tissue traction could be a major cause of subluxation or dislocation with hip flexion and internal rotation (Tanino et al., 2008). Such findings suggest that soft tissues might play an important role in dislocation after THA. In addition to these experimental investigations, several refined computer models have been developed (Delp et al., 1990). Although the existing model is sophisticated, it is not enough to satisfy our purpose as regards to accuracy of geometry and/or ability to predict dislocation. For accurate prediction of osseous or implant impingement, complete three-dimensional musculoskeletal geometry models are necessary. For the present study, a three-dimensional computer model combined with a Visual Basic program was developed to calculate muscle forces crossing the hip to predict soft-tissue traction and directions. The objective of this study was to introduce a musculoskeletal model developed by computer-aided design (CAD) to calculate and investigate the directions and magnitudes of muscle forces generated by hip muscles during passive movements and to investigate the effects of acetabular component (cup) anteversion angles on range of motion (ROM) and mechanisms of dislocation.

2. Methods

A three-dimensional CAD model of the pelvis and left femur with hybrid hip arthroplasty prostheses with a 26 mm femoral head (4-U; Nakashima Medical, Okayama, JP (Tanino et al., 2006)) and skeletal muscles crossing the hip joint was developed using CAD software (SolidWorks, Concord, MA) (Fig. 1). Some short external rotators were not modeled assuming a posterolateral surgical approach (Harris, 1980). Bone geometry was based on a commercially available human bone

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