Is High Flexion Following Total Knee Arthroplasty Safe?

Evaluation of Knee Joint Loads in the Patients During Maximal Flexion

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Abstract: The purpose of this study was to indicate the mechanical loads and the flexion angle at the knee during rise from maximal flexion following total knee arthroplasty (TKA). Twenty three knees were evaluated using skin marker-based motion analysis system during four different activities of daily living. The average maximum flexion was 90 degrees (34 degrees less than passive flexion) and all subjects required support for their weight to rise from maximal flexion. The external moments and the external forces at the knee during the maximal flexion were smaller than those during the stair descending activity. The results indicate that capable flexion angle for the patients following TKA is approximately 90 degrees which has smaller mechanical loads at the knee than the stair descending activity.
Key words: total knee arthroplasty, deep flexion, mechanical load, motion analysis, range of motion.

Total knee arthroplasty (TKA) has been used as a pain relief and a substitution of knee joint function. Most patients following TKA have achieved a significant degree of knee function, and have improved their ability to participate in various activities.

However, recent clinical evaluations have revealed that TKA still limits the patients in postoperative activities that require high flexion such as squatting and kneeling [1,2]. Su et al [3] examined the maximum flexion angle during rising from the low chair (65% of knee-heel height) following TKA was approximately 110 degrees, but how much flexion patients actually need in their ordinary life remains uncertain.

To acquire high flexion has been a current topic in TKA [4-8]. In fact, some patients achieved full flexion under the vigorous postoperative rehabilitation [9,10]. However, the previous studies on normal knees have shown that significant quadriceps moment, at least three to four times greater than the moment of level walking, is required to rise from full squatting position [11-13]. This significant muscle moment might not be reasonable for most TKA users over 60 years old because of the weakness of quadriceps muscle, even if they achieved full flexion following the surgery [14,15]. Furthermore, whether TKA, the artificial joint, is durable or not

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Submitted December 26, 2003; accepted July 20, 2004.
Benefits or funds were received in partial or total support of the research material described in this article from Zimmer GmbH.
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0883-5403/04/1906-0004$30.00/0
doi:10.1016/j.arth.2004.07.011

under excessive flexion and the mechanical loads in vivo during high flexion activities are not entirely clear. Recent in vitro studies revealed that the knee sustains higher mechanical stress in large flexion, although the joint loading due to the body weight and the muscle contractions were not sufficient to simulate in vivo condition in the studies [16,17].

The aim of this study was to evaluate the mechanical loads and the flexion angle at the knee during rising from maximal flexion in the patients following TKA. Therefore, we conducted the following analyses. First, the maximum knee flexion angle during high flexion activity was measured to evaluate a possible flexion angle in the patients with TKA during their ordinal work. Next, the joint loads were compared with those during regular ambulatory activities in order to indicate the relative mechanical demand during the high flexion activity. In addition, the knee mechanics of TKA was compared with that of the knee without the surgery in the patients who had uni-lateral TKA, in order to show the mechanical advantages of replaced joints in deep flexion.

Material and Methods

Twenty active patients, 2 men and 18 women at the age of 58 to 83 (average, 72), were recruited for this study. Patients with severe pain and those with a surgical history of joints except the knee were not included. All subjects had a post-operative period more than 6 months and the subjects with a good clinical score were selected (80 or more, according to the HSS score [18]). The abilities to ascend or descend a single-step staircase without any support and to perform rising from maximum flexion by one leg were particularly required. The subjects also had sufficient quadriceps strength (10 points by the HSS score, defined as "cannot break quadriceps") and their final range of motion was 100 degrees or more.

In pre-operative diagnoses, 16 of the 20 subjects had knee osteoarthritis and the remaining 4 subjects had rheumatoid arthritis. Two surgeons (TO and YS) operated on 23 TKA in total (osteoarthritis in 19 knees and rheumatoid arthritis in 4 knees, including 3 bilateral replacements) by using a standard parapatellar approach procedure with standard ligament-balancing followed by a constant tibial slope of 7 degrees. In all cases, posterior stabilized type prosthesis (LPS Flex, Zimmer, Warsaw, IN, USA) was used. The mobile bearing insert was used for 15 knees and the fixed bearing insert was used for the other 8 knees. Post-operative HSS score was 83 to 96 points (average, 92). The subjects were tested at the 6th to 28th month (average, 17th month) after the surgery.

Seventeen knees on the contra-lateral side of the subjects who have had uni-literal surgery were also tested in this study. Fourteen knees out of the seventeen knees had osteoarthritis and the other three had rheumatoid arthritis.

Before the examination, IRB approval for this study and informed consent were obtained for all subjects. The anthropometric measurement of limb was performed for the data processing, and a standard clinical goniometer was used to measure the passive range of motion. At the gait laboratory, all subjects performed the trials of 10m level walking, ascending and descending stairs, and rising up from the maximal flexion with one leg (Fig. 1). Six retro-reflective markers were placed on the limb to measure the sagittal kinematics during the motion [13,19]: three of six were at lateral joint lines of the hip, the knee and the ankle. The subjects were tested using a three-camera system (Pro-reflex, Qualysis, Sweden), and a force plate (AM6110, Bertec, Columbus, OH, USA) which obtains the ground reaction force during the motion. Three-dimensional knee kinetics was assessed by an inverse dynamics approach [19]. Two platforms, 21cm in height each, were used as staircases. Then, the first step onto the platforms was analyzed. A wooden box 56 cm in height was placed on the opposite side to the measured limb for the subjects to support their weight during rising from maximal flexion (Fig. 1).

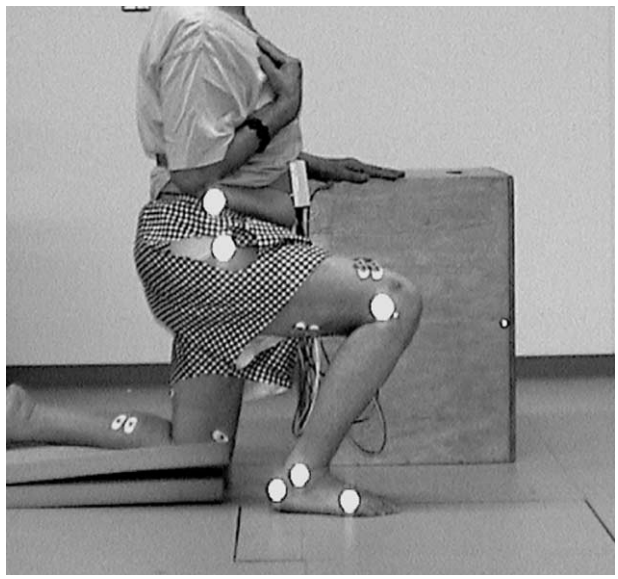

Fig. 1. Rising from maximal flexion using one leg. The patients used a wooden box to support their weight during the motion.