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Dynamic Measurements of Hip Movement in Deep Bending Activities After Total Hip Arthroplasty Using a 4-Dimensional Motion Analysis System

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Abstract: Although deep hip bending activities are often required in Asian populations because of traditional lifestyles and religious practices, few have examined the required hip range of motion (ROM) in these activities after total hip arthroplasty (THA). We performed postoperative motion analysis to evaluate the differences in required ROMs between Japanese-style and Western-style deep hip bending activities, to investigate whether prosthetic impingement would occur during these activities and to clarify the necessity for precautions in these activities after THA. Japanese-style activities did not require larger hip ROMs than Western-style ones, and all required hip flexion angles were less than 120°. Prosthetic impingement was not observed, with a safety margin 10° or higher until impingement in any directions of flexion, adduction, or internal rotation for any activities. Thus, particular postoperative precautions for Japanese-style activities are not required. **Keywords:** total hip arthroplasty, dynamic motion measurement, deep hip bending, 4D motion analysis, impingement.

Impingement between the neck of the stem and the rim of the cup is one cause of dislocation, wear or breakage of the neck and rim, or aseptic loosening of the cup after total hip arthroplasty (THA) [1,2]. Total hip arthroplasty with a prosthetic range of motion (ROM) larger than the patient's hip joint ROM may minimize such complications [3], but prosthetic ROM is also determined by implant orientation [4-6]. On the contrary, individual variations in the ROM used in daily activities also depend on cultural background. In Western countries, required ROMs of the hip have been analyzed in several common daily activities [7], revealing that appropriate prosthetic orientation can theoretically prevent prosthetic impingement without restrictions on daily activities common to the background lifestyle [8]. However, Asian and Middle Eastern countries require more frequent deep hip bending than Western countries because of traditional and religious practices [9]. Kneeling is often adopted for eating, socializing, and religious or traditional ceremonies. Squatting is the position usually adopted for defecation in Japan, China, India, and the Middle East [10]. However, no reports have described the required ROMs of the hip for these deep hip bending activities.

The purpose of this study was to measure the hip ROMs needed in several Japanese-style activities vs Western-style activities using a patient specific 4-dimensional motion analysis system [11,12]. We also ranked the activities' ROMs in order of flexion angle and clarified the need for hip precautions in the various activities.

Materials and Methods

We performed postoperative motion analyses for 62 Japanese female patients after obtaining informed consent. Patients who could perform postoperatively the following 6 motions safely were selected for this study: (1) sitting down on a chair with a height setting equal to the distance from the head of the fibula on the

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operated side to the floor, without a backrest; (2) getting up from a chair; (3) picking up an object while sitting on the chair; (4) squatting on the floor; (5) sitting on legs fully flexed at the knee ("Seiza" in Japanese); (6) bowing while sitting on legs fully flexed at the knee("Zarei" in Japanese) (Figs. 1-6). All patients had been diagnosed with osteoarthritis secondary to hip dysplasia and had undergone primary THA using a computed tomography (CT)-based navigation system (CT-Hip; Stryker, Mahwah, NJ). Cementless anatomical stems (CentPillar; Stryker) with a head 32 mm in diameter and cementless cups with polyethylene liners without elevated rims (Trident and Crossfire; Stryker) were used in all patients. We inserted the stem in the femur in line with the original femoral neck anteversion, which ranged from 5° to 55° [8]. Cup anteversion was based on the stem anteversion set at 10° increments while maintaining the radiographic inclination of the cup aimed at 40° (Table 1). This technique was a simplified version of the combined anteversion theory, and this combination of cup and stem anteversion provides impingement-free ROMs of more than 120° of flexion, 40° of extension, 40° of abduction, 40° of external rotation, and 40° of internal rotation in 90° of flexion with this design of hip implants [13]. Intraoperatively, we measured the stem and cup orientations using navigation with reference to the following femoral and pelvic coordinates [1]. The femoral coordinates were defined as follows: (1) the vertical axis referred to a line through the trochanteric fossa and the knee center and (2) the coronal plane was parallel to the table plane through the posterior prominence of the greater trochanter and the posterior femoral condyles. The pelvic coordinates were defined as follows: (1) the axial reference referred to the anterior

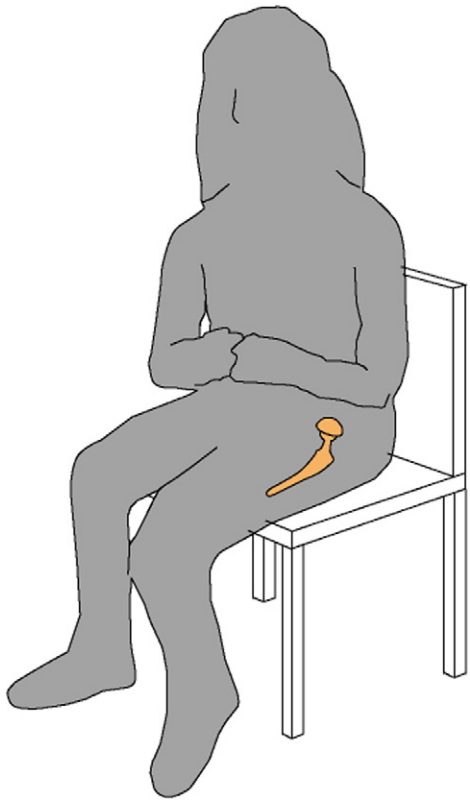

Fig. 1. Sitting down on a chair.

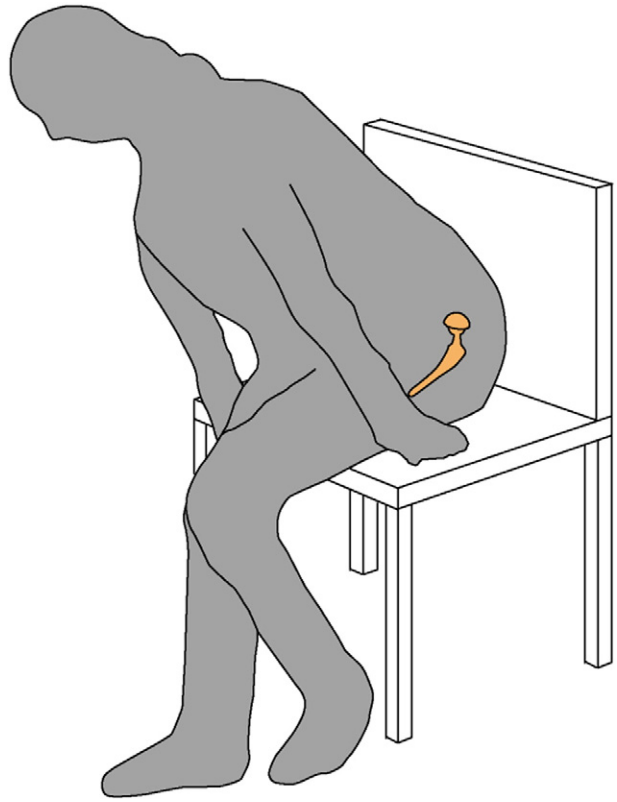

Fig. 2. Getting up from the chair.

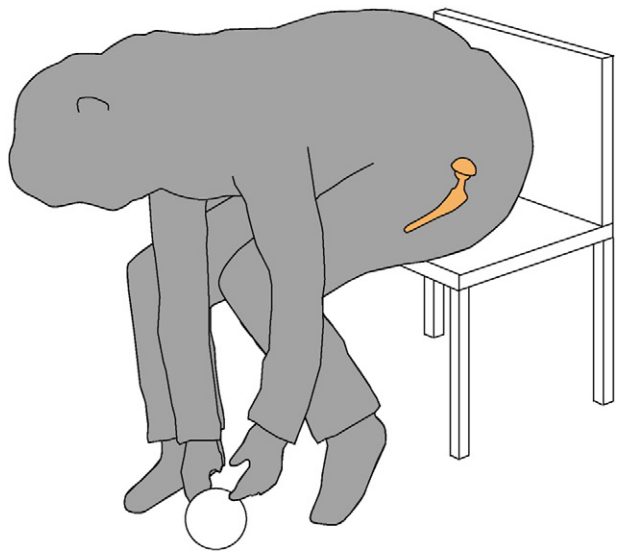

Fig. 3. Picking up an object while sitting on the chair.