CONTACT PRESSURE OF HIP JOINT DURING STRAIGHT LEG RAISING EXERCISE

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Introduction
Acetabular dysplasia is one of the major causes of osteoarthritis in young patients, in which the femoral head has insufficient coverage to bear physiological load. Consequently, the contact pressure of the hip joint increases and may initiate the degenerative change in articular cartilage. Muscle training exercise is usually carried out for those patients in Japan. However, there are a few reports about how much stress is applied on the joint cartilage during such exercises. Through experimental methods such as installing a sensor in vivo, the hip contact pressure during leg exercise was measured by Krebs et al[1]. However, there is no report about dysplastic hip joints. The objectives of this study were to (1) calculate the contact stress of hip joint during straight leg raising (SLR) exercise using a musculo-skeletal model of the human and (2) to know how SLR exercise affects hip joint surface.

Material and methods
The subjects were 6 hips of acetabular dysplasia women (average age was 36 years, CE angle varied from –6 to 18 degrees) and one hip of normal man (33 years, CE angle is 22 degrees) as a control. The maximum isokinetic muscular strength in SLR was measured by range of 0 to 30 degrees under angular velocity 30 degrees/s using KIN-COM. The lower extremity was divided into three segments; thigh, shank and foot. Each segment’s mass and moment of inertia were calculated by the landmarks of the body. The orientation of the muscles was calculated using the scaling method described by Brand et al[2]. The inter-segmental force and moment were calculated using inverse dynamic method, and muscle forces and joint resultant forces were calculated using optimization method. The stress distribution in the hip joint was calculated using discrete element analysis known as the rigid body spring modeling technique.

Results
(1) The magnitude of resultant force took maximum value at extensional position (5 degree of a hip flexion) and minimum at flexed position (30 degrees of hip flexion) in both normal and displastic hip joint and there was no significant difference between two groups (Fig. 1).
(2) The direction of resultant force showed a similar tendency by all subjects. It changed in rear 23 degrees from front 15 degrees for a body axis direction, and it was range of 11 degrees from a 9 degree to the inside (Fig. 2).
(3) The maximum contact stress of the hip joint was form 1.3 MPa. to 2.7MPa in a normal joint, whereas it was averaged 2.3 MPa to 32.3 MPa in displastic hip joints (Fig. 3). The stress was concentrated at the anterior-lateral edge of acetabulum in the extended hip position.

Discussion and conclusion
There are two main reasons why it is important to know the contact pressure distribution on dysplastic hip joints during muscle exercise. One is that intrinsic pathomechanical change in articular cartilage depends upon local stress levels rather than upon global joint loading. The other is that muscular strength training is applied for most cases in order to prevent muscular weakening and joint instability accompanied by the progress of osteoarthritis. From our results, in dysplastic hip joints, high stress was concentrated at the anterior-lateral edge of the acetabulum in the extended hip position. The average value of the stress was much higher than the normal case in spite of resultant force itself was smaller than the normal one. It can be explained as follows: The action direction of the rectus femoris and the iliopsoas, which are main actuator of SLR, turns to frontal in hip extended position. Therefore, the resultant force of the hip joint is forwardly directed, where the coverage of acetabulumu is much smaller in dysplastic hips. As a result, high stress concentration was produced at anterior-lateral edge of acetabulum. We concluded that SLR exercise with a hip extended position is not desirable as physical therapy for dysplastic hip joints.

Reference
1) Krebs D.E., Physical Therapy, 71:301-309

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Fig.1 the resultant force

Fig.2 the resultant force angle

Fig.3 the maximum contact pressure of the