IMPORTANCE OF PROPRIOCEPTION AFTER TOTAL HIP REPLACEMENT

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ABSTRACT
The biomechanical analysis of the lower extremity is common. It generally involves gait analysis, measuring the kinematic and kinetic parameters of gait. The aim of our study is to find a reproducible, precise, dynamic measuring method, which is able to analyze the proprioception of the lower limb during gait and to observe the effect of different operative methods for THR. 49 patients (35 females, 14 males) with unilateral primary osteoarthritis (OA) of the hip joint were selected for our study. The patients were divided into four groups (traditional antero-lateral and direct-lateral approach, minimalized posterior and minimalized direct-lateral approach) and according to the implantation technique of prostheses. Proprioception was examined by a Zebris CMS10 ultrasound-based measuring system, connected to a Zebris Posturomed device, which is a movable and adjustable plate. The patients were examined by the preformed tests of the Zebris WinPosture software such as the ‘Provocation test’, ‘Stepping test’, ‘Lower extremity test’, and ‘Pelvis-shoulder test’ before operation, and on the 2nd, 6th, and 12th weeks after operation, both in a fixed and a moving examining plate. Investigated parameters include damping time, elevation of knee joint, pelvis and shoulder rotation. On the basis of the results it could be established that our ultrasound-based dynamic measuring system was able to perform reproducible measurements of proprioception. This measuring method is able to detect the effect of different THR implantation techniques on proprioception. On the 2nd postoperative week the biomechanical parameters are significantly less in patients operated with the capsule retaining technique, even when standing on both lower limbs and on the operated limb as well. This is due to the undeveloped proprioception of capsule extirpated patients.

KEY WORDS
Biomechanics, kinematics, hip joint, proprioception, damping time

1. Introduction
Osteoarthritis (OA) is one of the most common musculoskeletal complains worldwide. It is characterized by pain, disability and progressive loss of function and is associated with significant health and welfare costs. The hip is the most frequently affected joint of the lower limb. As prevalence of knee OA increases with age, the overall burden of the disease is expected to increase given the ageing of the population. Patients with hip OA report pain and difficulty with functional activities such as prolonged sitting, ascending and descending stairs, walking, squatting, kneeling, rising from a chair and getting in and out of a car. Ultimately these limitations lead to loss of functional independence and reduced quality of life. Physical function depends upon many physiological parameters including muscle strength, sensory input from proprioception, visual and vestibular system, intact balance mechanism, range of motion and higher cortical function. Impairments in these parameters are likely to contribute to disability.

Neuromotor control of the hip involves the coordinated activity of surrounding muscles. This co-ordinated activity provides active stability of the hip joint thus assisting in the absorption of much of the load placed on the hip joint during weight-bearing activities. Hip joint proprioception, afferent information from mechanoreceptors in the muscle, ligaments, capsule and skin contribute at the spinal level to arthrokinetic and muscular reflex which play a large part in dynamic joint stability.

The biomechanical analysis of the lower extremity is common. It generally involves gait analysis, measuring the kinematic and kinetic parameters of gait. These
analyses are frequently used in the field of orthopaedics all over the world [1,2,4,8].

The effect of the osteoarthritis of the hip joint and total hip replacement (THR) on the kinetic and kinematic parameters of gait is well documented [5, 6]. The results show that the co-ordination of surrounding muscles are changed significantly [3,7,9]. However few studies have investigated the proprioception of lower extremities before the implantation and in first week after the implantation.

This research is aimed to produce a test method and corresponding biomechanical parameters suitable for modeling the proprioception of lower extremities A further objective is to identify the influence of different implantation techniques of prostheses on the proprioception of lower extremities.

2. Materials and Methods

Subjects
49 patients (35 females, 14 males) with unilateral primary osteoarthritis (OA) of the hip joint were selected for our study. The unilateral OA of the hip joint was verified by physical examination and anterior-posterior and lateral x-ray according to Kellgreen-Lawrence. 16 patients had grade III and 33 patients had grade IV osteoarthritis. All of the selected patients had pain in their everyday life and a limited range of hip motion. Patients with a former hip operation as well as with any kind of disease involving the vestibular and locomotor systems or vision were excluded from the study. Exclusion criteria also included any neurological deficits (e.g. polyneuropathy), history of diabetes and restricted mobility.

The patients were divided into four groups according to the implantation technique of prostheses. Group I (6 males, 6 females; mean age 61 years) had a traditional antero-lateral approach with extirpation of the joint capsule. Group II (5 males, 13 females; mean age 60 years) had a direct-lateral approach with extirpation of the joint capsule. Group III (3 males, 10 females; mean age 61 years) had a posterior approach with retention of the hip joint capsule. Group IV (6 females; mean age 55 years) had a minimalized direct-lateral approach, retaining the joint capsule. Hip endoprostheses implantations were performed by two senior orthopaedic surgeons. One of them operated groups I and III, and the other operated groups II and IV. The patients had the same postoperative care, including physiotherapy.

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Methods, investigated parameters
Proprioception was examined by a Zebris CMS10 ultrasound-based measuring system, connected to a Zebris Posturomed device (Figure 1), which is a movable and adjustable plate. The patients were examined by the preformed tests of the Zebris WinPosture software such as the ‘Provocation test’, ‘Stepping test’, ‘Lower extremity test’, and ‘Pelvis-shoulder test’ before operation, and on the 2\textsuperscript{nd}, 6\textsuperscript{th}, and 12\textsuperscript{th} weeks after operation, both in a fixed and a moving examining plate (Figure 2). In order to record knee joint motion, markers were placed onto tuberositas tibia (Figure 2), onto ASIS to record pelvis motion and onto the acromion to record shoulder motion. The movements of the Posturomed device can be recorded by markers that can be fastened to the plate. The measurement control software enables us to determine the spatial coordinates of the sensors from the dispersion time of the ultrasound recorded by the measurement system using the triangulation method. Before all measurements the SF-36 and WOMAC life quality test were filled in by the patients, and the physical examination of the patients was performed according to the Harris Hip Score.

Figure 1: Zebris Posturomed device
Figure 2: Measurement arrangement for recording the knee joint motion

In the course of a movement test, the measurement system records the changes through time of the spatial coordinates of designated anatomical points. The following kinematic parameters were calculated from spatial coordinates: (1) damping time of measuring plate, (2) elevation of knee joint, (3-4) pelvis and shoulder rotation.

Statistical analysis
In case of each subject examined, we calculated the average and the standard deviation of the kinematic characteristics and muscle activity periods calculated from the measurement results of the motion cycles recorded, and these data were further processed. The biomechanical properties of individuals pertaining to a given group and those of various groups were statistically analyzed using the MS Excel Analysis Tool Pak software. The average and standard deviation of the biomechanical properties of individuals pertaining to a given group were calculated. The uniformity of standard deviations was checked by an F-test; significance levels of the difference between the average values of identical parameters were determined by a t-test applying a symmetrical critical range. A one-sample t-test was applied when comparing the results at different times. For comparisons among four groups, simultaneous multiple comparisons were made by analysis of variance (ANOVA). The results present statistically significant differences if p < 0.05.

3. Results

The damping time of the examining plate is significantly lower on the 2nd week postoperatively at the patients operated with the hip joint capsule retaining technique (Figure 3). The difference between the groups decreases in the longer postoperative period, but even after 12 weeks group III has got a lower damping time than the others.

On the postoperative 2nd week the step height is decreased because of neuromuscular defense in all four examined groups Figure 4). The decrease of step height in groups III and IV - operated with the joint capsule retaining technique - is significantly less than in the groups with capsule extirpation.

On the 2nd postoperative week the shoulder rotation increases (Figure 5) and the pelvis rotation (Figure 6) decreases in all four groups. The biggest decrease in pelvis rotation range of motion (ROM) and the compensatory increase in shoulder ROM occurs in group III. That is in consequence of the operative technique, the detachment of rotator muscles.

Figure 3: Damping time of examination plate in seconds after provocation, standing on operated lower limb
4. Discussion

After THR the pelvis ROM in flexion decreases, and even on the 12th postoperative week it is less than preoperatively. Between the 2nd and 6th postoperative weeks, the ROM of the shoulder increases and changes in the opposite compared to the rotation ROM of the hip.

Small hip rotation is a consequence of big shoulder rotation. The decrease in pelvis rotation ROM and the increase of shoulder ROM preserving the rotation in the postoperative period is significantly larger in the group operated by a posterior approach than in the other groups. If the movement was not in proper order before operation,
then it does not change on the 2nd postoperative week. On the 2nd postoperative week the damping time of the examining plate is significantly less in patients operated with the capsule retaining technique, even when standing on both lower limbs and on the operated limb as well. This is due to the undeveloped proprioception of capsule extirpated patients.

In the postoperative period THR implantation modifies gait parameters at the contralateral side as well, e.g. less step height detected at contralateral lower limb postoperatively. The step height in patients operated with the capsule retaining method is significantly higher from the 2nd to 12th postoperative weeks than in those with capsule extirpation. On the 2nd postoperative week the damping time of the examining plate is significantly less in patients operated with the capsule retaining technique, even when standing on both lower limbs and on the operated limb as well. This is due to the undeveloped proprioception of capsule extirpated patients.

5. Conclusion
Our ultrasound based dynamic measuring system is able to perform reproducible measurements of proprioception. This measuring method is able to detect the effect of different THR implantation techniques on proprioception. On the basis of the results it could be established that capsule extirpation significantly impairs the proprioception of operated patients. No significant differences between the different operation methods could be detected 6 weeks after the surgery.

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References