SURGICAL APPROACH IN TOTAL HIP ARTHROPLASTY CAUSES LONG TERM DIFFERENCES IN PERIPROSTHETIC FEMORAL BONE DENSITIES

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Introduction: Periprosthetic bone loss is one of the greatest problems in total hip arthroplasty (THA). A number of factors have been identified that deteriorate bone mass, e.g., gender, body weight, but also design criteria of the femoral stem, such as prosthesis size and rigidity. The long term outcomes of different implant designs have been less pronounced than expected and the bone loss after THA was characterized by a large inter-individual variability. Until recently, however, little attention has been given to the influence of the surgical approach and the extent of soft tissue trauma on the periprosthetic mineral density (BMD). The musculature surrounding the hip is altered as a result of preoperative pain and morphology, but especially by the selected surgical approach. The goal of the present study was to compare the change in musculo-skeletal loading and periprosthetic BMD in relation to the alteration of the musculature after the anterolateral and transgluteal surgical approaches in THA.

Methods: 150 patients with primary osteoarthrosis received an elective cementless primary arthroplasty (Alloclassic, Sulzer Medica, Wintherthur, Switzerland). 52 patients with 67 artificial hip joints were available at a six year follow up period. Group A comprised 30 hip joints in 25 patients who had received a hip endoprosthesis via the anterolateral (abductor split) approach. Group B included 37 hip joints (27 patients) in which the transgluteal (lateral) approach had been used. Each surgical approach was conducted by a single surgeon with a minimum of 500 primary implantations (Group A: HZ; Group B: CP). The average ages of the patients at the time of surgery were 63.7 (group A) and 55.8 (B) years, and at follow-up were 69.5 (A, average 5.8 years post op) and 61.3 (B, average 5.5 years post op) years. No significant differences were detected between groups in respect to age and gender distribution as well as in respect to average stem size or the ratio of prosthesis stem/femoral canal filling in a Wilcoxen test (confidence interval: 95%, p<0.05). The clinical assessment was performed by a single investigator using the Harris Hip Score. Quantitative measurements of BMD were performed using DEXA on a DPX-L densitometer (Lunar, Cologne, Germany). Measurements were taken of the proximal femur until 2 cm distally of the tip of the prosthesis with the patient in a fixed supine position. Anterior-posterior scans were taken at 3 mA and 76 kV with a graphic resolution of 0.6 x 1.2 mm. The BMD values were then averaged within each of the seven different Gruen zones. The t-test and Mann-Whitney U test (SPSS Inc, Chicago, IL) were used to evaluate differences between groups. The significance level was set to 95% (p<0.05). The study was approved by the local ethics committee.

The musculo-skeletal loading conditions of the lower limb were evaluated using a previously reported, validated numerical model. A computer model of the bones and muscles of the human lower extremities (CT-data, Visible Human, NLM, USA) was scaled to match the anatomies of 4 THA patients with telemetric prostheses, including the individual position of the femoral implant component. Gait analysis data for walking and stair climbing (ground reactions, limb positions, velocities, and accelerations) was determined simultaneously with in vivo hip contact forces. Muscle and joint contact forces were calculated throughout the gait cycle for both activities and validated against the in vivo measured hip contact forces. To simulate the estimated damage caused during the transgluteal approach, the physiological cross sectional areas (PCSA) of the major abductor muscles (gluteus medius) were reduced by 30%, thus limiting the maximum transmittable force in the tissue. The resulting muscle force distribution and hip contact forces were then calculated for the 4 patients during both activities.

Results: There were no significant differences in the functional outcomes between both groups postoperatively. The Harris Hip Score improved from a mean of 38 (range 3 to 65) points to 82 (range 36 to 100) in group A versus an improvement from a mean of 38 (range 13 to 63) to 86 (range 41 to 100) in group B. The radiological evaluation did not show any significant migration or any other signs of loosening of the femoral or acetabular component in either group, nor did any of the prostheses undergo revision. The osteodensitometric measurements showed a significant reduction in BMD (t=1) in all seven different Gruen zones I, II, VI and VII after the transgluteal approach (group B) compared with the anterolateral approach (group A). In zones II, VI and VII, the reduction of BMD was highly significant (p<0.01). Remarkably, the reduction affected not only the lateral but also the medial proximal Gruen zones.

A reduction of the capacity of the gluteus medius by 30% after a simulated transgluteal approach led to a considerable redistribution of the musculo-skeletal loading across the hip joint: While the forces in the muscles attaching directly at the proximal femur (single joint muscles) were generally lower (max. 21%, Fig. 1), the forces in the muscles spanning the hip and the knee (two joint muscles) increased by up to 57%. Overall, the weakening of the major abductors increased the hip contact forces by 10% (min: 8, max: 12%) during walking and by 8% (min: 4, max: 12%) during stair climbing.

Discussion: Periprosthetic bone loss poses a major challenge to the long term performance of hip endoprostheses. The findings of the present study demonstrate the influence of two different surgical approaches on musculo-skeletal loading and long term periprosthetic bone loss. The redistribution of muscle forces at the proximal femur, as shown by the computer model, corresponded with the reduced BMD in the proximal Gruen zones. Although the damaged soft tissues surrounding the hip would recover in a relatively short period of time, this redistribution of muscle forces might cause a long term adaptation of the loading conditions at the hip and therefore alter the bone remodeling as seen in the clinical study.

Based on the data presented in this study, future research and development on hip endoprostheses should focus on a muscle-sparing implantation. However, long-term and randomized, prospective studies are necessary to further elucidate this question.

References: