Journal of US-China Medical Science 13 (2016) 129-137
doi: 10.17265/1548-6648/2016.03.002

Leg Length Discrepancy after Total Hip Arthroplasty Using the Modified Anterolateral Approach for Stable Hip

Michitaka Kato, Hideki Warashina and Shinji Kitamura

Department of Orthopaedic Surgery, Nagoya Joint Replacement Orthopaedic Clinic, Kita-Nagoya City, Aichi Prefecture 481-00111, Japan

Abstract: BACKGROUND: The modified Dall approach is a modified anterolateral approach with osteotomy of the anterior part of the greater trochanter. OBJECTIVES: We aimed to evaluate the adequacy of the modified Dall approach by measuring leg length discrepancy and evaluating offset discrepancy using postoperative radiographs. METHODS: Of 103 cases of total hip arthroplasty (THA), 22 patients (mean age, 66.6 ± 12 years) with > 120° flexion angle on the affected hip (mean, 127.2° ± 6.1°), almost normal opposite hip, and low leg-length discrepancy were included. A stem was inserted, and an appropriate ball neck size was selected to ensure hip stability and avoid dislocation during trial reduction. The ball head inserted had a diameter of 26 mm, and the cup position was at the anatomical hip center. RESULTS: The mean preoperative and postoperative leg length discrepancies were 5.8 ± 6.3 and 0.7 ± 3.5 mm, respectively, the mean postoperative offset discrepancy was 0.7 ± 6.6 mm, and no dislocations occurred. DISCUSSION: We have been using the modified Dall approach for several years. It has yielded minimal leg length discrepancy after THA, with preservation of soft tissue tension. To date, there have been no reports on this procedure, and our results show that it offers maximal stability and minimal leg length discrepancy.

Key words: Total hip arthroplasty, leg length discrepancy, offset discrepancy, approach, THA stability.

1. Introduction

Performing total hip arthroplasty (THA) on patients with primary osteoarthritis, osteonecrosis, and femoral neck fractures without resultant leg length discrepancy and with a good range of motion and stable postoperative hip joint is a challenging task for surgeons. Leg length discrepancy, with the longer leg on the THA side and a normal opposite hip joint, may result in patient dissatisfaction [2], gait disorder [3], greater trochanter pain [4], nerve palsy [5], low back pain, and increased oxygen consumption and heart rate [6]. Low soft tissue tension with no leg length discrepancy may also bring about dislocation.

The advantages of THA using the modified Dall approach [1], compared with the Hardinge approach, are good operation field, good stability of the hip joint, and probable improved recovery of the released tissues of the gluteus medius and vastus lateralis [7]. The Dall approach is a modified anterolateral approach (modified Hardinge approach) with osteotomy of the anterior part of the greater trochanter where the anterior parts of the gluteus medius and vastus lateralis attach. This approach can relatively preserve soft tissue tension during surgery because all posterior muscles and most of the iliofemoral ligament function are preserved because of the exposure of the operation field with minimal soft tissue release. However, the original Dall approach leads to some complications on the greater trochanter. A fracture on the greater trochanter may occur postoperatively due to the fragility of the greater trochanter. Another complication is the nonunion of the region of osteotomy on the greater trochanter. Thus, a modified Dall approach was used, which only involved small

Corresponding author: Michitaka Kato, MD, research field: orthopaedics.

osteotomy and low amount of gluteus medius release.

The aim of this study was to evaluate the adequacy of this method through the measurement of leg length discrepancy and the offset of any discrepancies using postoperative radiographs.

2. Methods

2.1. Patients

This study was performed retrospectively. Among 103 patients who underwent THA from September 2011 to October 2013, 22 patients with >120° of affected hip flexion angle (including the pelvic tilt angle) and almost normal opposite hip and with a low leg length discrepancy were selected. The follow-up rate of the 103 patients who underwent THA was 94.6%.

The mean age of the 22 subjects was 66.6 ± 12 years (range, 43-85 years). The diagnoses for surgery included secondary osteoarthritis in 12 hips, primary osteoarthritis in 4 hips, osteonecrosis in 4 hips, and femoral neck fracture in 2 hips.

The mean flexion angle of the preoperative hip joints was 127.2° ± 6.1° (range, 120°-140°). The hip flexion mean inclination angle of the pin inserted in the pelvis was 11.9° (range 6°-20°; standard deviation, 4.3°), which indicated that the pelvic tilt compensated for about 10° of the hip flexion. The angle between the femur and the pelvis was therefore about 110°.

2.2. Surgical Technique

Preoperative radiological templating is done in all cases to control leg length discrepancy by ± 5 mm and to avoid hip dislocation during intraoperative trial reduction. The templating cup is aligned with the anatomical hip center and ensures no leg length discrepancy. THA, using the modified Hardinge approach, is then performed, ensuring that the iliofemoral ligament is preserved. The modified anterolateral approach for stable hip (MAASH) involves the insertion of a stem and selection of an appropriate ball neck size for hip stability and to avoid dislocation.

While the patient is under anesthesia and in a supine position, a 2.8-mm-diameter Steinmann pin is inserted into the non-operative side anterior to the superior iliac spine and driven in with a drill, perpendicular to the operating table, as an acetabular alignment guide. The hip joint of the operative side is then passively flexed and the hip flexion angle and tilting angle of the pin are measured using a goniometer (Fig. 1). A pin is then inserted into the anterior superior iliac spine of the operative side. An alignment guide is then placed. If

Fig. 1 Measurement of the flexion angle of the hip joint using a goniometer during the operation and the insertion of a pin into the anterior superior iliac spine, which was initially inserted perpendicular to the operating table. At full flexion of the hip joint, the pin tilts to an obtuse angle, due to the tilting of the pelvic bone.

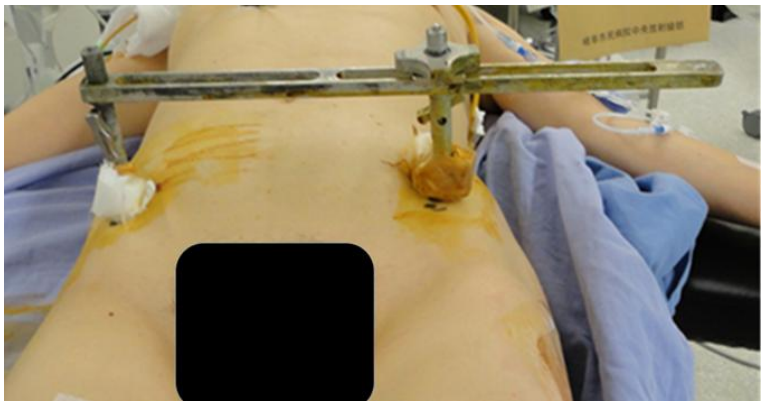

Fig. 2 The acetabular alignment guide is attached, and with this as the plane of reference, the orientation of the acetabular component is established three-dimensionally.

the hip flexion angle is < 90°, the desired cup radiographic anteversion is 5°-10°, owing to the risk of low posterior dislocation. If the hip flexion is > 90°, the desired cup radiographic anteversion is 15°. The stem is usually fixed at an anteversion, from 15° to 25°. An acetabular alignment guide is then attached, and with this as the plane of reference, the orientation of the acetabular component is established three-dimensionally (Fig. 2). The patient is then positioned in lateral decubitus position. Tilting the pelvis so that it is slightly angled to a supine position makes the view of the acetabulum more accessible.

Approximately 10 to 12 cm of oblique skin incision is made 1 or 2 cm proximal to the posterior corner of the greater trochanter and through the innominate trabecula to the anterior of the femur. A Charnley compact-type retractor is used to expose the operation field, and the iliotibial ligament is then incised along the line of the previous skin incision.

A third of the anterior part of the gluteus medium is detached. Osteotomy was performed on the anterior part of the greater trochanter using a chisel (length × depth × width, 25 × 15 × 5 mm). A third of the vastus lateralis is longitudinally incised. The hip joint is externally rotated, and the anterior part of the capsule is released. After which, the lateral part of capsule is incised up to the edge of the acetabulum toward the 12-o'clock direction.

The femoral head is then dislocated anteriorly by flexion adduction and external rotation. If dislocating the hip is difficult, osteotomy of the femoral neck is performed, and the femoral head is then resected using a Steinmann pin and thread. Osteotomy of the femoral neck is performed to the level of preoperative planning. A pin retractor is then hammered into the pelvic bone at the anterosuperior point, 1 to 2 cm from the acetabulum. The femur is then retracted to the posteroinferior acetabular edge using a modified horizontal retractor, which is used to spread open the muscles between the pin retractor and the proximal femur. This is done by inserting the horizontal retractor and turning the T-handle to the right, which causes the hooks to open and spreads open the muscles, thus providing a clearer view of the operation field.

In some cases, it is difficult to expose the acetabulum completely and to not retract the femoral calcar. In these cases, the surgeon should ask the assistant to pull the leg and spread the horizontal retractor (Fig. 3) with force. If it remains too difficult to expose the acetabulum, additional femoral neck osteotomy may be required, as it may have been originally too long or not properly angled.

Two Hohmann retractors are then placed on the anterior side and on the posterosuperior side of the acetabulum. It is important for the iliofemoral ligament to have strong tension, but it must not release or resect when the preoperative leg length discrepancy is only small. A third retractor is placed in the obturator foramen and is then attached to the frame of the Charnley retractor with a gauze, which provides a good

Fig. 3 The horizontal retractor.

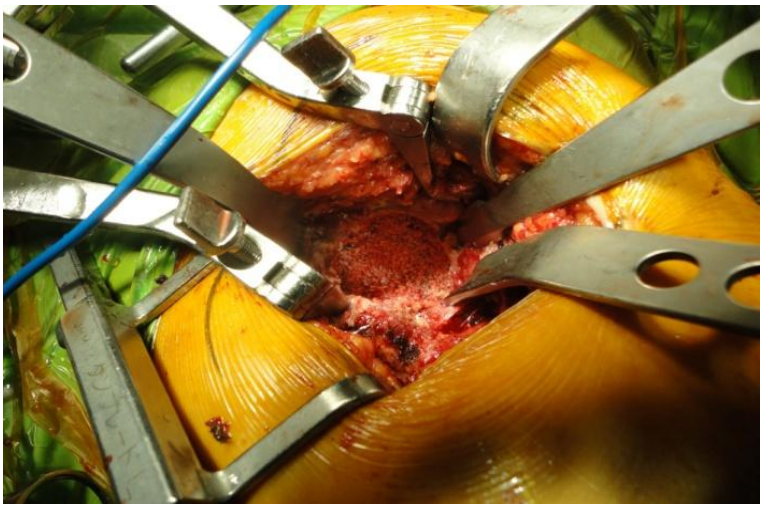

Fig. 4 Accurate placement of the retractor is important to have a good view of the acetabulum.

view of the entire acetabulum (Fig. 4). By pushing the third retractor medially, the operation field is expanded where necessary.

The cup component is implanted at the optimal angles for cup insertion using an acetabular alignment guide. On average, the target cup position should have a 42° inclination angle and a 15° radiographic anteversion angle. The cup is fixed at the anatomical hip position.

During the exposure of the femoral side, the leg is positioned with roughly 40° flexion and 90° external rotation and adduction. The posterior soft tissue of the proximal femur is not released. A single, straight, metal elevator is placed on the posterior side of the calcar osteotomy to allow exposure of the proximal femoral canal. The femoral canal is prepared according to a standard technique, and a trial reduction is performed. At 0° extension with slight adduction, maximum external rotation to the leg is performed to confirm that there is no anterior dislocation. Toward the end of the operation, the bone fragment of the greater trochanter is fixed with three polyester sutures (size 5, ETHIBOND EXCEL®; Ethicon, Skillman, NJ, USA) through three drill holes made by a 2.5-mm diameter

k-wire in the greater trochanter.

All THAs were performed with cement fixation, using an alignment guide to ensure accurate acetabular positioning. A cross-linked polyethylene cup and a cemented collarless polished tapered straight stem (SC-stem; Kyocera, Kyoto, Japan) were used in all patients. A 26-cm-diameter ball head was used. All the cement cups were fixed at the anatomical hip position.

2.3. Measurement of Leg Length Discrepancy and Offset

Measurements of leg length discrepancy, femoral offset, and cup alignment were performed on plane anteroposterior radiographs of the bilateral hip in the supine position. Anteversion confirmed that the cup was not facing posteriorly.

The global offset is the distance measured along the perpendicular line between the femoral axis of the proximal femur and the teardrop (Fig. 5). The discrepancy in the offset is calculated by subtracting the measurement of the global offset on the THA side from the normal side.

Leg length discrepancy is calculated by subtracting the distance from the lesser trochanter and line A on the operative side from the same distance (area between the lesser trochanter and line A) on the nonoperative side.

3. Results

The mean angle of the cup inclination was 43.8° ± 11.9° (36°-50°) and that of the radiographic anteversion was 11.8° ± 6° (0°-20°). The mean preoperative and postoperative leg length discrepancies were -5.8 ± 6.3 and 0.7 ± 3.5 mm, respectively. Three patients had lengthening of the postoperative legs by >5 mm (7, 8, and 9 mm), but none had > 10-mm lengthening in comparison to the non-operative side. The results of this research show minimal postoperative leg length discrepancy and global offset, with values of 0.7 ± 3.5 and 0.7 ± 6 mm, respectively. No dislocations occurred in this series of 103 cases. One of our patients was a 63-year-old woman whose preoperative radiograph revealed dysplastic hip osteoarthritis in her right hip joint and leg length discrepancy of 5 mm. The preoperative right hip flexion angle was 124°, measured while the patient was under anesthesia. THA was performed on her right hip joint, as discussed during preoperative planning. Postoperative radiograph showed no leg length discrepancy or change in the global offset, compared with preoperative radiograph (Fig. 6).

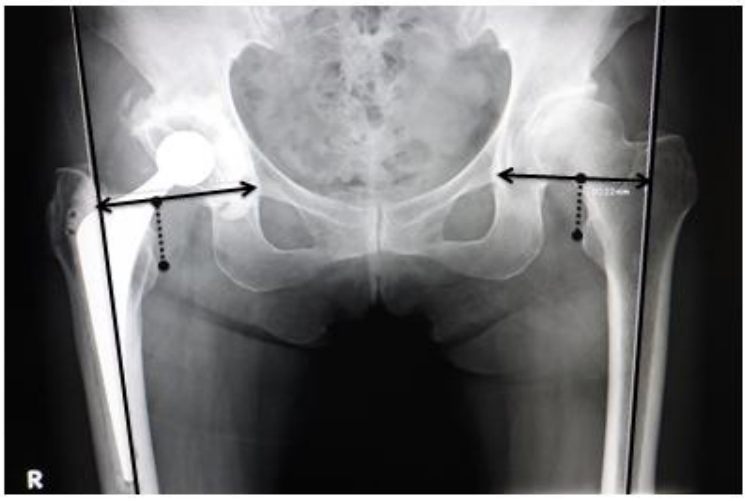

Fig. 5 Measurement of the global offset.

Fig. 6 Patient radiographs before and after total hip arthroplasty. Data show no postoperative leg length discrepancy and that the global offset discrepancy was equal to 6 mm, both preoperatively and postoperatively.

4. Discussion

One of the major complications after THA is leg length discrepancy, which can sometimes result in litigation [8]. Sykes et al. [9] reported that for discrepancies ≥ 5 mm, a significant number of participants were aware of the difference. They also noted that the patients who underwent THA who perceived a difference in their limb lengths postoperatively had significantly worse pain and Oxford scores compared with those who perceived their limb lengths to be equal [9]. Mahmood et al. [10] reported that patients whose limbs lengthened by > 9 mm after THA had higher incidence of shoe lift use, residual hip pain, limb length discrepancy awareness, and use of walking aids [10].

The primary reason for longer leg length, postoperatively, is the need for good soft tissue tension and to ensure that the joint does not dislocate. Leg length discrepancy is more likely to occur in patients who have very flexible hip joints, low preoperative leg length discrepancy, osteonecrosis, primary osteoarthritis, dysplastic hip osteoarthritis (Crowe 1 and 2), or femoral neck fractures. Good soft tissue tension is important for THA to prevent the hip joint from dislocating during trial reduction, and iliofemoral ligament tension should be preserved as much as possible during THA so as not to lengthen the leg when using the modified Dall approach.

The risk factors of dislocation have two categories: (1) those due to medical implications including approach [11], offset [12], implant alignment [14], head diameter of implant [15], etc.; (2) those centered around the patient's health condition or around any other personal implications, including obesity [16], rheumatoid arthritis [17], older age [18], good range of motion of the hip joint [19], cerebral dysfunction [20], etc.

The following practices can be done to prevent dislocation:

(1) Use of a cup alignment guide. The cup alignment must be in the safe zone [22] and the cup position must be at the anatomical hip center.

(2) Preservation of posterior soft tissues (except for the capsule).

(3) Preservation of the functions of the iliofemoral and pubofemoral ligaments. These ligaments are minimally detached at the femur.

(4) Stem anteversion should be between 15° and 25°.

(5) Use of an appropriate ball neck size to avoid dislocation with maximal external rotation. Femoral offsets are not strictly controlled, but the difference in femoral offsets after THA between the affected and the unaffected side should be minimal.

Sometimes the offset should be slightly adjusted, and this can be done using two different methods. The

first method is to alter the cup setting position, and the second is to increase the stem insertion depth and select a longer neck length. According to our research, postoperatively, no case of longer leg length discrepancy has been reported when these techniques were used.

Our research shows that the iliofemoral ligament is essential for anterior stability and should not be released during THA when using this approach, especially if there is little or no discrepancy in the leg length of the patient preoperatively. One of the advantages of the transgluteal approach is that one is able to preserve the iliofemoral ligament and keep the posterior side muscles intact to ensure good stability of the hip joint. If a patient requires lengthening during THA, the iliofemoral ligament is released or resected, which in turn lengthens the affected leg. A good operation field while ensuring the preservation of the iliofemoral ligament and soft tissue tension is important. The correct positioning of the pin retractor is critical. If the pin retractor is positioned too far away from the acetabulum, the tension in the iliofemoral ligament is increased. The horizontal retractor should spread with force while the leg is being tracked by an assistant. When the retractor is inserted into the obturator foramen, the assistant should pull at the leg, which will make the insertion of the retractor easier. When femoral neck osteotomy is performed, it is important that it be performed at the correct level and with the appropriate angle.

The disadvantages of the Hardinge approach are occasional detachment and unsuccessful reattachment of the released conjoined membranes of the vastus lateralis and gluteus medius. Intraoperatively, these muscles should be connected to the bone at the attachment of the gluteus medius and vastus lateralis to maintain the connection of the two muscles and to increase the possibility of re-union, as Dall reported [1]. Another disadvantage of the Dall approach is the potential trouble with the greater trochanter, such as fractures and non-union of the fragments. A fracture of the greater trochanter is a catastrophic complication. During the osteotomy of the greater trochanter, one must be careful not to cause a large fragment, especially in cases where the greater trochanter is vulnerable, due to rheumatoid arthritis or osteoporosis. In those cases, the Hardinge approach may be a better choice than the Dall approach. Nonunion of the fragment of the greater trochanter is frequently recognized, but its effect on the hip function is not clinically significant in many cases.

Kanoh et al. [21] reported that cup alignment is a useful method with which to achieve accurate and reproducible acetabular positioning in primary THA. During this research series, the mean angle of the cup inclination was 43.8° ± 11.9° (range, 36°-50°) and the mean angle of the radiographic anteversion was 11.8° ± 6° (0°-20°). The inclination angles of all cases fell within Lewinnek' safe zone [22]. Radiographic anteversion angles were also within an acceptable range. The risk of dislocation was reduced by accurately positioning the cup position using the cup alignment guide.

The head implant that selected had a diameter of 26 mm, which aided in the longevity of the joint; however, due to its small size, it was more prone to dislocation [23].

Three months after THA, none of the patients was restricted in their daily activities and there were no cases of dislocation. All patients involved this study reported in that they were able to crouch at 6 months after THA in the activities of daily living questionnaire.

Mahmood et al. [10] reported that shortening of leg length was not a risk factor of dislocation after THA; however, good soft tissue tension, which usually prevents dislocation, can sometimes result in leg length discrepancy. Using the modified anterolateral approach for THA, soft tissue tension can be relatively preserved during the operation, and therefore, there is a lesser chance of leg length discrepancy postoperatively. It is important for the hip joint to be stable; this is ensured by preserving the short rotator muscles and piriformis,

which act as posterior stabilizers, and the iliofemoral ligament and pubofemoral ligament, which act as anterior stabilizers. Delgado et al. [24] reported that the MAASH is a modification of the classical Hardinge approach, but it specifically preserves the anterior iliofemoral lateral ligament and pubofemoral ligament. MAASH offers maximal stability and the ability to restore leg length accurately [24].

After about 3 months, almost none of the patients who underwent THA were restricted in their activities of daily living. Both the Dall and Harding approaches offer excellent stability while restoring leg length accurately. The advantages of the modified Dall approach are its excellent operation field and good soft tissue tension. Trial reductions are easily performed with the Dall approach, which, however, are more difficult when using the MAASH approach [24]. The Dall approach is widely used with Crowe 3 and 4 type or revision surgery.

The present study has certain limitations: first is the small sample size; thus, this study should be reevaluated using a larger sample size in the future. Second, the femoral offsets were evaluated in two dimensions. Therefore, if the normal hip offset decreased with external rotation, it increased with internal rotation. The radiographer thus had to ensure that the pelvis was set parallel to the plane of the film without rotation or flexion of the hip joint and that the leg was placed in a neutral position with the patella positioned forward. A further limitation is that there was no radiographic evaluation of the leg length of the full lower extremities, and in rare cases, the leg length of the right and left legs is slightly different below the lesser trochanter.

In conclusion, the modified anterolateral approach preserved much of the iliofemoral ligament function and ensured that the implantation is performed without dislocation during trial reduction, leading to minimal postoperative leg length discrepancy and offset discrepancy. The patients involved in this study had stable THA, and there were no cases of dislocation. Postoperatively, they had unrestricted activities of daily living, for example, there was no difficulty going into squatting position.

References

[1] Dall, D. 1986. "Exposure of the Hip by Anterior Osteotomy of the Greater Trochanter. A Modified Anterolateral Approach." *J. Bone Joint Surg. Br.* 68 (3): 382-6.

[2] Wylde, V., Whitehouse, S. L., Taylor, A. H., Pattison, G. T., Bannister, G. C., and Blom, A. W. 2009. "Prevalence and Functional Impact of Patient Perceived Leg length discrepancy after hip replacement." *Int. Orthop.* 33 (4): 905-9.

[3] Tanaka, R., Shigematsu, M., Motooka, T., Mawatari, M., and Hotokebuchi, T. 2010. "Factors Influencing the Improvement of Gait Ability after Total Hip Arthroplasty." *J. Arthroplasty* 25 (6): 982-5.

[4] Sayed-Noor, A. S., and Sjoden, G. O. 2006. "Greater Trochanteric Pain after Total Hip Arthroplasty: The Incidence, Clinical Outcome and Associated Factors." *Hip Int.* 16 (3): 202-6.

[5] Hofmann, A. A., and Skrzynski, M. C. 2000. "Leg-length Inequality and Nerve Palsy in Total Hip Arthroplasty: A Lawyer Awaits!" *Orthopedics* 23 (9): 943-4.

[6] Clark, C. R., Huddleston, H. D., Schoch, E. P., and Thomas, B. J. 2006. "Leg-length Discrepancy after Total Hip Arthroplasty." *J. Am. Acad. Orthop. Surg.* 14 (1): 38-45.

[7] Hardinge, K. 1982. "The Direct Lateral Approach to the Hip." *J. Bone. Joint Surg. Br.* 64 (1): 17-9.

[8] McWilliams, A. B., Douglas, S. L., Redmond, A. C., Grainger, A. J., O'Connor, P. J., Stewart, T. D., and Stoneet, M. H. 2013. "Litigation after Hip and Knee Replacement in the National Health Service." *Bone Joint J.* 95-B (1): 122-6.

[9] Sykes, A., Hill, J., Orr, J., Humphreys, P., Rooney, A., Morrow, E., and Beverland, D. 2015. "Patients' Perception of Leg Length Discrepancy Post Total Hip Arthroplasty." *Hip Int.* 25 (5): 452-6.

[10] Mahmood, S. S., Mukka, S. S., Crnalic, S., and Sayed-Noor, A. S. 2015. "The Influence of Leg Length Discrepancy after Total Hip Arthroplasty on Function and Quality of Life: A Prospective Cohort Study." *J. Arthroplasty* 30 (9): 1638-42.

[11] Tsukada, S., and Wakui, M. 2015. "Lower Dislocation Rate Following Total Hip Arthroplasty via Direct Anterior Approach than via Posterior Approach: Five-Year-Average Follow-Up Results." *Open Orthop. J.* 15 (9): 157-62.

[12] Robinson, M. I., Bornstein, L., Mennear, B., Bostrom, M., Nestor, B., Padgett, D., and Westrich, G. 2012. "Effect of Restoration of Combined Offset on Stability of Large Head THA." *Hip. Int.* 22 (3): 248-53.

[13] Masonis, J. L., and Bourne, R. B. 2002. "Surgical Approach, Abductor Function, and Total Hip Arthroplasty Dislocation." *Clin. Orthop. Relat. Res.* 405: 46-53.

[14] Daines, B. K., and Dennis, D. A. 2012. "The Importance of Acetabular Component Position in Total Hip Arthroplasty." *Orthop. Clin. North. Am.* 43 (5): 23-34.

[15] Woo, R. Y., and Morrey, B. F. 1982. "Dislocations after Total Hip Arthroplasty." *J. Bone Joint Surg. Am.* 64 (9): 1295-306.

[16] Liu, W., Wahafu, T., Cheng, M., Cheng, T., Zhang, Y., and Zhang, X. 2015. "The Influence of Obesity on Primary Total Hip Arthroplasty Outcomes: A Meta-analysis of Prospective Cohort Studies." *Orthop. Traumatol. Surg. Res.* 101 (3): 289-96.

[17] Khatod, M., Barber, T., Paxton, E., Namba, R., and Fithian, D. 2006. "An Analysis of the Risk of Hip Dislocation with a Contemporary Total Joint Registry." *Clin. Orthop. Relat. Res.* 447: 19-23.

[18] Girard, J., Kern, G., Migaud, H., Delaunay, C., Ramdane, N., Hamadouche, M; Société française de chirurgie orthopédique et traumatologique. 2013. "Primary Total Hip Arthroplasty Revision Due to Dislocation: Prospective French Multicenter Study." *Orthop. Traumatol. Surg. Res.* 99 (5): 549-53.

[19] Gregory, R. J., Gibson, M. J., and Moran, C. G. 1991. "Dislocation after Primary Arthroplasty for Subcapital Fracture of the Hip. Wide Range of Movement Is a Risk Factor." *J. Bone Joint Surg. Br.* 73 (1): 11-2.

[20] Woolson, S. T., and Rahimtoola, Z. O. 1999. "Risk Factors for Dislocation during the First 3 Months after Primary Total Hip Replacement." *J. Arthroplasty* 14 (6): 662-8.

[21] Kanoh, T., Hasegawa, Y., Masui, T., Yamaguchi, J., Kawabe, K., and Ishiguro, N. 2010. "Accurate Acetabular Component Orientation after Total Hip Arthroplasty Using an Acetabular Alignment Guide." *J. Arthroplasty* 25 (1): 81-6.

[22] Lewinnek, G. E., Lewis, J. L., Tarr, R., Compere, C. L., and Zimmerman, J. R. 1978. "Dislocation after Total Hip Replacement Arthroplasty." *J. Bone Joint Surg.* 60-A: 217-20.

[23] Jameson, S. S., Lees, D., and James, P. 2011. "Lower Rate of Dislocation with Increased Femoral Head Size after Primary Hip Replacement: A Five-year Analysis of NHS Patients in England." *J. Bone Joint Surg. Br.* 93 (7): 876-80.

[24] Delgado, F. G., Broch, A., Reina, F., Ximeno, L., Torras, D., García, F., and Salvador, A. 2013. "MAASH Technique for Total Hip Arthroplasty: A Capsular Work." *HSS J.* 9 (2): 171-9.