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A New Minimally Invasive Transsartorial Approach for Periacetabular Osteotomy

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Background: A new minimally invasive transsartorial approach for the Bernese periacetabular osteotomy was developed. We investigated whether this technique was safe and successful with regard to minimizing tissue trauma and, more importantly, whether it was possible to obtain optimal reorientation of the acetabulum.

Methods: Our experience with this approach was retrospectively assessed by means of database inquiry and the evaluation of radiographs. We assessed ninety-four procedures performed between April 2003 and August 2005 to determine perioperative and early postoperative outcome measures, the achieved acetabular reorientation, and hip joint survival.

Results: The mean duration of surgery was 73.1 minutes, the median perioperative blood loss was 250 mL, and the mean reduction in the hemoglobin level was 33 g/L. Blood transfusion was required following 3% of the procedures. No injuries to the great vessels or nerves, arterial thromboses, unintended extension of the osteotomy, or deep infections occurred. The postoperative acetabular reorientation was assessed by measuring the center-edge and acetabular index angles, the medians of which were 34° and 3°, respectively. With total hip arthroplasty as the end point, the hip joint survival rate was estimated to be 98% at 4.3 years.

Conclusions: Osteotomy with use of this minimally invasive transsartorial approach appears to be a safe, relatively short surgical procedure associated with a relatively small amount of blood loss and minimal transfusion requirements. Optimal acetabular reorientation can be achieved with this technique.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Ganz et al. described a technique of periacetabular osteotomy in 1988[1]. It is an extensive surgical procedure performed in young adults with acetabular dysplasia[2-11]. The acetabulum is reoriented in order to optimize its coverage of the femoral head, thereby changing the pathological hip joint mechanics that can cause early osteoarthritis[12-20].

The learning curve associated with this procedure is well documented, and technical and neurovascular complications have been reported by experienced surgeons[1,7,21-25]. The occurrence of complications is greatly influenced by the experience of the surgeon and the choice of surgical approach[23,25]. Several approaches for the Bernese periacetabular osteotomy are characterized by relatively extensive incisions and dissection and may require muscle detachment[1,3-5,25-28]. The most commonly used approaches are the modified Smith-Petersen (iliofemoral) and the ilioinguinal approaches[3-5,21,25,28].

A new, minimally invasive, transsartorial approach for the periacetabular osteotomy was developed by the senior au-

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thor (K.S.). The primary aim of this approach was to minimize the tissue trauma during dissection. As a result, the duration of surgery, blood loss, transfusion requirements, and length of hospital stay may be minimized. However, it is necessary for this approach to be safe, and the rate of complications should be lower or comparable with that of currently accepted techniques. The reorientation of the acetabulum should not be compromised, since it is the cornerstone of the procedure. The purpose of this study was to investigate if this new approach is safe and does not adversely affect optimal acetabular reorientation.

Materials and Methods

We retrospectively assessed our experience with the minimally invasive transsartorial approach by means of database inquiry and evaluation of radiographs. Between April 2003 and August 2005, this approach was used in 122 patients (125 procedures, three of which were bilateral) undergoing periacetabular osteotomy. All patients were operated on by the senior author (K.S.). The approach was used in consecutive patients, with no selection. Our indications for the osteotomy were symptomatic acetabular dysplasia defined by persistent hip pain and a center-edge angle of Wiberg[29] of <25°, a congruent hip joint, no or early signs of osteoarthritis (Tönnis grade[30] 0 or 1), hip flexion of >110°, and internal rotation of >15°.

Study Group

All patients who had been operated on with use of the periacetabular osteotomy between April 2003 and August 2005 were eligible for inclusion. In order to provide a well-defined study group, we excluded patients who had not undergone surgery with hypotensive epidural anesthesia (three patients), patients who had had supplemental hip surgery (hardware removal, intertrochanteric osteotomy, or cheilectomy; nine patients), and those with Legg-Calvé-Perthes disease (nineteen patients). Ninety-one patients who had undergone a total of ninety-four procedures (three of which were bilateral) satisfied the criteria and comprised the study group. At the time of surgery, the mean age of the patients was 37.2 years (95% confidence interval, 34.9 to 39.5 years), their mean weight was 68.5 kg (95% confidence interval, 66.1 to 70.8 kg), and seventy-six (84%) were women. The duration of follow-up for assessment of hip joint survival in the study group ranged from 2.0 to 4.3 years.

Clinical and Radiographic Evaluation

The study group was assessed with respect to the duration of the surgery, perioperative blood loss, reduction in hemoglobin level, transfusion requirements, complications, length of hospital stay, reorientation of the acetabulum, and need for a subsequent total hip arthroplasty. Data regarding age, gender, weight, diagnosis, length of hospital stay, previous surgery, surgical approach, method of anesthesia, duration of surgery, perioperative blood loss, perioperative supplemental surgery, transfusion requirements, and complications had been recorded in a database assigned to the Danish Hip Arthroplasty Register. Furthermore, preoperative and postoperative blood specimens had been taken routinely from all patients for determination of hemoglobin values, and anteroposterior pelvic radiographs had been made routinely for all patients. Patients who had a subsequent total hip arthroplasty in a Danish hospital were registered in the Danish Hip Arthroplasty Register. Therefore, patients who were living outside of Denmark (five patients treated with a total of seven procedures [two bilateral]) were not available for the hip joint survival analysis. The duration of surgery was measured from the start of the skin incision to the completion of the skin closure. The perioperative blood loss was estimated on the basis of the volume of blood in the suction bottles and swabs in the operating room. A blood transfusion was not performed during any of the procedures. Postoperative blood transfusion was prescribed on the basis of clinical symptoms of anemia.

Moderate and severe complications (that is, an injury to the great vessels or nerves, an arterial thrombosis, unintended extension of the osteotomy into the joint or through the posterior column, or deep infection) were recorded in the database. Minor complications (such as dysesthesia of the lateral femoral cutaneous nerve, delayed union, or heterotopic ossification) were not. The orientation of the acetabulum was determined by measuring the center-edge angle of Wiberg[29] and the acetabular index angle of Tönnis[30]. The center-edge angle is formed by two lines, both running through the center of the femoral head. The first line is perpendicular to the pelvic reference line, and the second line is drawn from the most lateral margin of the acetabular sclerotic roof. The acetabular index angle is formed by two lines, both originating at the most medial margin of the sclerotic acetabular roof. The first line is parallel to the pelvic reference line, and the second line is drawn to the most lateral margin of the sclerotic acetabular roof. The same observer (A.T.) made the measurements on both preoperative and postoperative anteroposterior pelvic radiographs. Radiographs related to seven procedures were missing or of inferior quality (excessive tilt or rotation) and were excluded from evaluation. The hemoglobin values related to seven procedures were also excluded either because they were missing (one procedure) or because the patient had had a bilateral procedure. The weight data for one patient were missing from the register. Data were complete for the remaining parameters.

Surgical Technique

The patient is placed on a radiolucent operating room table in the supine position. The placement of the drapes allows full mobilization of the lower extremity on the operatively treated side. Fluoroscopic evaluation is necessary throughout the operation, and therefore the pelvis is kept in a neutral position in order to avoid excessive tilting or rotation. The fluoroscopy equipment is positioned to facilitate the attainment of anteroposterior and 60° (false-profile) views.

The skin incision begins at the anterior superior iliac spine and continues distally along the sartorius muscle. The length of the incision is approximately 7 cm. The fascia is carefully incised, and the lateral femoral cutaneous nerve is isolated and carefully retracted. To facilitate transverse retraction of the soft tissues, a semiflexed position of the hip joint is maintained during performance of the osteotomies. A splint is used for this purpose. A periosteal elevator is placed subperiosteally along the medial aspect of the ilium, starting at the anterior superior iliac spine, and is advanced until it lies just below the linea terminalis. The inguinal ligament is cut at the attachment to the anterior superior iliac spine, allowing further mobilization of the soft tissues. The periosteal elevator is then pushed medially, splitting the sartorius muscle in the direction of its fibers, and the deep fascia of the muscle is cut. The periosteal elevator is then replaced with a blunt retractor positioned along the medial aspect of the ilium to retract the iliopsoas muscle and the medial part of the split sartorius muscle medially. At this point, the osteotomies are performed (Fig. 1). We estimate that approximately ten minutes is spent on the approach. A detailed technical description of the periacetabular osteotomy is presented in the Appendix.

Statistical Analysis

Normally distributed data are presented as means with 95% confidence intervals. Data that are not normally distributed are presented as medians with interquartile ranges. The surgeon's learning curve with respect to the duration of surgery and perioperative blood loss was analyzed with linear regression analysis. Kaplan-Meier survival analysis was performed with a subsequent total hip arthroplasty as the end point. The level of significance was set at $p < 0.05$.

TABLE I Clinical Measures Associated with the Minimally Invasive Transsartorial Approach

Measurement	
Median length of hospital stay (interquartile range) *(days)*	8 (7-9)
Mean duration of surgery (95% confidence interval) *(min)*	73.1 (70.5-75.8)
Median perioperative blood loss (interquartile range) *(mL)*	250 (150-350)
Mean preoperative hemoglobin level (95% confidence interval) *(g/L)*	138 (136-140)
Mean reduction in hemoglobin level (95% confidence interval) *(g/L)*	33 (31-35)
No. (%) of procedures followed by transfusion	3 (3%)
Median no. of blood units transfused (range)	2 (2-3)

Results

Clinical Outcome

The median length of the hospital stay was eight days (interquartile range, seven to nine days), the mean duration of the surgery was 73.1 minutes (95% confidence interval, 70.5 to 75.8 minutes), and the median measured perioperative blood loss was 250 mL (interquartile range, 150 to 350 mL)

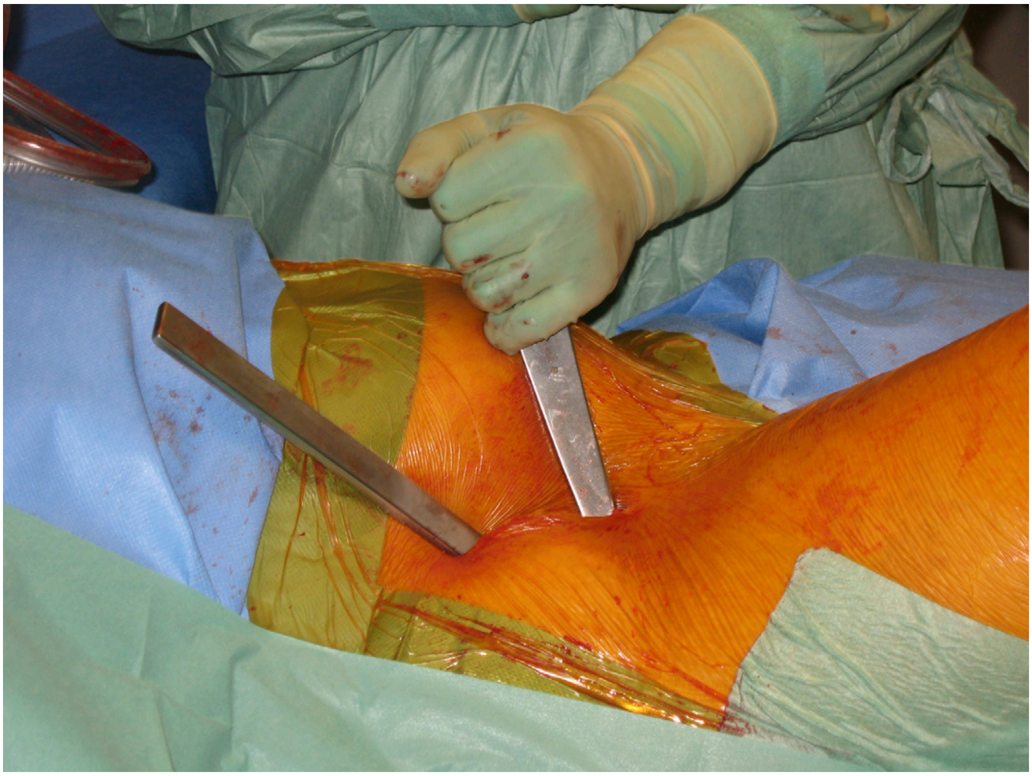

Fig. 1

Performance of the osteotomy through the minimally invasive transsartorial approach. A straight osteotome is used to perform the last step of the ilium osteotomy, with a retractor protecting the medial structures (see Appendix for details).

TABLE II Radiographic Measurements Associated with the Minimally Invasive Transsartorial Approach

Measurement	
Median center-edge angle of Wiberg (interquartile range) *(deg)*	
Preoperative	15 (6-19)
Postoperative	34 (29-36)
Median acetabular index angle of Tönnis (interquartile range) *(deg)*	
Preoperative	17 (14-23)
Postoperative	3 (0-7)

(Table I). No particular learning curve for the surgeon was identified by the linear regression analysis, which demonstrated a negligible decrease in the duration of surgery ($r = -0.05$). There was no significant relationship between the number of procedures performed and the duration of surgery ($p = 0.35$). Blood transfusions were required following 3% (three) of the ninety-four procedures, with a median of two (range, two to three) units of blood (280 mL of erythrocyte suspension) transfused. The mean preoperative hemoglobin level was 138 g/L (95% confidence interval, 136 to 140 g/L). The mean reduction in the hemoglobin level was 33 g/L (95% confidence interval, 31 to 35 g/L) (Table I). With conversion to total hip arthroplasty as the end point, the Kaplan-Meier analysis showed a hip joint survival rate of 98% at 4.3 years (range of follow-up, 2.0 to 4.3 years) (Fig. 2). There were two conversions to total hip arthroplasty, one at 1.8 years and one at 2.7 years after the osteotomy.

Complications

There were no arterial thromboses, injuries of the iliac or femoral artery or vein, injuries of the femoral or sciatic nerve, or direct injuries of the lateral femoral cutaneous nerve. There were no observed instances of unintended extension of the osteotomy through the posterior column or into the joint. There were no wound infections requiring surgical intervention.

Radiographic Outcome

The median center-edge angle was 15° (interquartile range, 6° to 19°) preoperatively and 34° (interquartile range, 29° to 36°) postoperatively. The median acetabular index angle was 17° (interquartile range, 14° to 23°) preoperatively and 3° (interquartile range, 0° to 7°) postoperatively (Table II). The distributions of the preoperative and postoperative center-edge and acetabular index angles are presented in the Appendix.

Discussion

Periacetabular osteotomy is an extensive surgical procedure, and the most commonly used approaches are associated with relatively extensive tissue trauma[1,5,25,28]. In an attempt to minimize the tissue trauma caused by incision, dissection, and detachment of muscles, the senior author (K.S.) developed a minimally invasive approach for the procedure. In the pre-

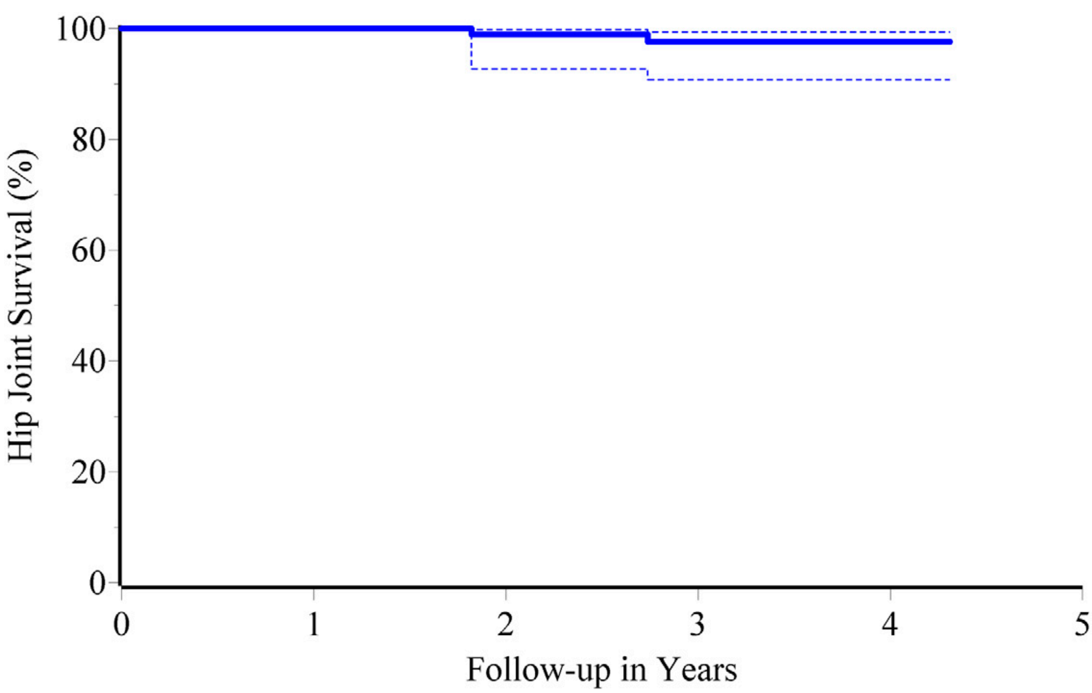

Fig. 2

Kaplan-Meier hip joint survivorship curve with 95% confidence intervals for eighty-seven periacetabular osteotomies (seven procedures in patients living outside of Denmark were excluded) with conversion to a total hip arthroplasty as the end point. The duration of follow-up was 2.0 to 4.3 years.

sent study, we attempted to determine if this approach was safe and did not compromise the achieved reorientation of the acetabulum.

The minimally invasive characteristics of this approach are evident at all stages of the procedure and are not defined by the length of the skin incision. No muscles are detached, and the only muscle that is directly affected is the sartorius, which is split in the direction of the fibers. The tissue trauma is further minimized by the relatively brief duration of the surgery (mean, 73.1 minutes), which is due in part to the limited time spent on the approach and closure. The relatively small perioperative blood loss and low transfusion requirements also suggest minimal soft-tissue trauma. However, all blood loss may not be recognized with use of the methods for assessing perioperative blood loss that we employed[31]. The duration of the surgery, perioperative blood loss, and transfusion requirements with our technique compare favorably with those associated with other techniques reported in the literature[1-5,7,23,27]. Trousdale and Cabanela reported an average blood loss of 350 mL in patients treated through an iliofemoral approach[24]. Siebenrock et al. reported that the patients in their study required transfusion of a mean of four units (range, one to eleven units) of blood, but approximately 25% of those patients had simultaneous supplemental surgery[2]. The duration of the hospital stay that we reported is similar to the seven to ten-day durations reported by authors who had used different surgical approaches[4,5,27].

When a transsartorial approach is used, the sartorius and iliopsoas muscles protect the femoral vessels and nerve against direct and indirect damage. The abductor muscles are spared, and the acetabular blood supply is therefore left intact. We observed no moderate or severe neurovascular or technical complications. When iliofemoral approaches are used, the prevalence of moderate or severe technical and neurovascular complications should be less than 2% to 3%[1,23,25]. Minor complications were not registered in the database, and we did not evaluate them in this study. Such minor complications include dysesthesia of the lateral femoral cutaneous nerve, which was reported to have occurred after approximately 30% of more than 700 periacetabular osteotomies performed through the modified Smith-Petersen (iliofemoral) approach[25].

The median postoperative center-edge and acetabular index angles of 34° and 3°, respectively, show that acceptable acetabular reorientation was achieved. The distribution of the postoperative angle measurements shows that nearly normal alignment was obtained in a high proportion of patients. We aim for an acetabular index angle of 0° to 10° and a center-edge angle of 30° to 40°; however, this amount of correction might not be achieved if the hip is severely dysplastic. Since September 1999, we have used a measuring device to assist in surgical decision-making during the reorientation procedure. The device provides measurements of the perioperative center-edge and acetabular index angles with the use of fluoroscopy. Even though we do not perform an extensive soft-tissue dissection, we have not experienced technical problems, and the achieved angle measures are comparable with those reported in what we believe are the largest study groups in the literature[2,3,7].

Hip joint survivorship analysis with total hip arthroplasty as the end point estimated a survival rate of 98% at 4.3 years. There were only two short-term conversions to total hip arthroplasty (both in hips that were Tönnis grade 1 preoperatively). The high survival rate was likely due to our indications for performing the periacetabular osteotomy. In a previous study[32] in which short-term hip joint survivorship was reported with total hip arthroplasty or an additional osteotomy as the end point, the lowest survival rates were found in patients with moderate or severe osteoarthritis (Tönnis grade 2 or 3).

The minimally invasive approach limits direct visualization of the osteotomies. This could increase the risk of intra-articular extension of the osteotomy or extension of the osteotomy through the posterior column[22]. However, with use of the fluoroscopic technique that we described (see Appendix), no such cases were observed. We estimate that the average fluoroscopy time was approximately thirty-five seconds.

It is not possible to access the labrum or other intra-articular structures with this approach, and some surgeons may find this to be a major limitation. However, we do not consider intra-articular assessment to be necessary.

It is important to recognize that there is a learning curve related to this procedure[1,21-24]. The experience of the surgeon is an important factor that greatly influences the result. When this minimally invasive approach was initiated, the senior author had already accumulated great experience with respect to the details of the reorientation procedure by previously performing 143 Bernese periacetabular osteotomies. Furthermore, this study did not demonstrate a significant relationship between the number of procedures performed and the duration of the surgery. We recommend that only a surgeon with previous experience with the performance of periacetabular osteotomy consider using our minimally invasive approach.

Our results suggest that this minimally invasive approach is safe and successful in minimizing tissue trauma. There were no moderate or severe technical or neurovascular complications in our series. The postoperative center-edge and acetabular index angles were highly satisfactory. All procedures were performed by an experienced surgeon, and it is not known whether these results can be achieved by less experienced surgeons. This and the full scope of benefits and disadvantages of the approach will need to be revealed in subsequent studies.

Appendix

eA Details of the periacetabular osteotomy and the distributions of the center-edge and acetabular index angles before and after the surgery are available with the electronic versions of this article, on our web site at jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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