TOTAL HIP ARTHROPLASTY AFTER PERI-ACETABULAR OSTEOTOMY RESULTS IN SIGNIFICANT IMPROVEMENT IN HIP FUNCTION WITH LOW REVISION RATES AT MID-TERM FOLLOW-UP

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ABSTRACT

Background: Bernese periacetabular osteotomy (PAO) improves symptoms and delays degenerative changes in patients with acetabular dysplasia. Yet, eventual total hip arthroplasty (THA) is needed in many of these patients. The impact of PAO on subsequent THA outcomes is not well defined.

The purpose of this study is to define: 1) clinical outcomes, 2) post-operative complications and 3) implant survivorship for patients undergoing THA after prior ipsilateral PAO.

Methods: A retrospective review was conducted at three institutions to identify individuals undergoing THA after ipsilateral PAO surgery with minimum 1 year follow up. Patient reported outcome measures (PROMs) were collected preoperatively and at final follow-up. Surgical details, radiographic and clinical outcomes, and major complications according to the modified Dindo-Clavien classification system were identified through review of the medical record. Regression analysis and student's t-test were used to compare pre- and post-operative outcome scores. Kaplan-Meier analysis was performed to estimate reoperation-free survivorship.

Results: A total of 113 THA in 112 patients were identified with initial review. 103 hips had a minimum of 1-year follow-up and an average follow of 5 ± 4 years (range, 1 to 20). 10 hips (9%) were lost to follow-up leaving 103 (91%) hips available for review with a minimum of 1-year follow-up (mean = 5 years). Mean interval from PAO to THA was 7.7 years (range, 2-15). The average post-operative mHHS improved 37 points (50 to 87, P < 0.001) when compared to pre-operative scores. Eight patients (7.1%) experienced a major grades III-V) surgical complication. These included 2 cases of instability, 2 cases of acetabular loosening, and one case each of periprosthetic fracture, wound dehiscence, periprosthetic infection, acetabular loosening and pneumonia. Failures occurred early at average 3.2 years and survivorship analysis for all-cause revision demonstrated 96% survivorship at both 5 and 10 years.

Conclusion: THA after PAO achieves significant clinical improvement and satisfactory survivorship (96%) at mid-term follow-up, with a major complication rate of 7.1%.

Level of Evidence: III

Keywords: total hip arthroplasty, periacetabular osteotomy, survivorship, mid-term follow-up, young adult

INTRODUCTION

Acetabular dysplasia of the hip results in premature degenerative changes through labral injury and chondral shear,[1] thereby pre-disposing individuals with dysplasia to hip pain and end-stage osteoarthritis. Bernese periacetabular osteotomy (PAO) in this patient population can not only provide symptomatic relief and restore function[2] through re-orientation of the acetabulum, but also serves to alter the natural history of the hip by preventing degenerative changes from occurring.[3] Moreover, the benefits of this procedure can be realized with minimal surgical morbidity,[2] particularly once a surgeon progresses through their respective "learning curve".[4] As such, the relative utilization of the PAO has expanded beyond isolated dysplasia in the young adult hip to include numerous other conditions: symptomatic borderline dysplasia,[5] dysplasia in the setting of mild degenerative changes,[6] deformity as a sequalae of Legg-Calve-Perthes,[7] and dysplasia in the setting of spastic cerebral palsy.[8]

Despite the relative success of PAO in both improving symptoms and reducing degenerative changes, approximately 26-40% of individuals will undergo THA

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at 20 years[9] after PAO. Given the excellent results of THA – even in younger[10] and more active patients[11] – concerns may exist that PAO may demonstrate a deleterious effect on subsequent THA. These concerns may be well-founded, as individuals with prior open (i.e., open reduction internal fixation of an acetabulum fracture[12] and hip hemi-arthroplasty[13]) or arthroscopic[14] procedures about the hip demonstrate higher rates of complication, when compared to patients undergoing primary total hip arthroplasty without previous procedures. Unique to the PAO population, retained hardware, disruption of surgical planes, abnormal femoral morphology, and loss of landmarks for acetabular cup placement may all contribute to increased technical difficulty or adverse outcomes at time of THA. Given a subset of patients (i.e., slightly older patients or patients with early degenerative changes) may be reasonable candidates for either PAO or THA, understanding the impact of PAO on THA is essential for both patient counseling and surgical indications.

Currently, the understanding of surgical impact of THA after PAO is limited to smaller (<40 patients), single-center, or single-surgeon studies,[15,16,17] which yield conflicting data regarding clinical outcomes and surgical complications. As such, this three-institution, retrospective study was designed to answer two major questions. 1) What are the clinical outcomes and complications of THA after previous PAO surgery? 2) What is the mid-term survivorship of THA after previous PAO surgery? The hypotheses of this study are that patients undergoing THA after PAO will demonstrate a significant improvement in hip function with an acceptable surgical complication risk and excellent long-term survivorship.

METHODS

This study retrospective review was performed at three centers and cases were performed between the years 1994 and 2020. All procedures were performed by high-volume surgeons with fellowship training in adult reconstruction. Implant selection, surgical approach, and post-operative rehabilitation were conducted at the discretion of the treating surgeon. Individuals were eligible for inclusion in this study if the underwent THA after previous Bernese PAO. Patients with previous non Bernese PAO were excluded or those where the type of osteotomy was unknown. Institutional review board approval was obtained.

Demographic data including patient sex, age, self-identified race, and body mass index (BMI) were all obtained through chart review. Operating time was defined as the interval from incision to wound closure, to obviate the impact of induction of anesthesia, patient positioning, and post-operative processes. The modified Harris Hip Score (mHHS) was collected pre-operatively and post-operatively at a minimum of one year. The most recent available follow-up scores were used for the purpose of this analysis. Major peri-operative complications were recorded according to the Clavien-Dindo Classification adapted by Sink et al.,[18] including grades III, IV, and V.

Radiological parameters which were recorded included cup abduction angle (as measured on the AP radiograph) and cup anteversion[19] (as measured on the cross-table lateral radiograph). The Lewinnek safe zone[20] was utilized to assess acceptable acetabular component positioning defined by cup abduction angle from 30 to 50 degrees and cup anteversion angle from 5 to 25 degrees. Implant material, fixation method, and geometry data was also recorded.

Regression analysis and student's t-test were used to compare pre- and post-operative outcome scores. Kaplan-Meier analysis was performed to estimate reoperation-free survivorship. Statistical significance was defined as a $p<0.05$.

RESULTS

A total of 113 hips in 112 patients were identified with initial review. 103 hips were had a minimum of 1-year follow-up and an average follow of 5 ± 4 years (range, 1 to 20). Ten hips (9%) were lost to follow-up leaving 103 hips for analysis. All 103 hips had complete outcomes data and 84% had complete radiographic data. Most patients were female (n= 92, 81%). The mean BMI was 27.9 (SD 5.7). The average time from PAO to THA was 7.7 years (range 2-15). Average age at the time of THA was 40 years (range, 16-67). Surgical details, implants and acetabular component position are displayed in Table 1.

Average mHHS score improvement was 37 points (50 to 87, $p < 0.001$). Eight (7.1%) major complications occurred in the post-operative period: 1 re-admission for pneumonia at 1 week post op, 1 late peri-prosthetic femoral fracture at 2 years treated with revision, 1 wound dehiscence at 1 months requiring operative intervention, 1 peri-prosthetic infection at 1 month treated with DAIR, 2 instance of aseptic acetabular loosening treated with revision at 3.2 and 17.7 years, 1 revision for instability at one year post op and 2 hip dislocations in one patient (treated with closed reduction). Most failures occurred early at average 3.2 years and survivorship analysis for all-cause revision demonstrates 96% survivorship at 5 and 10 years (Table 2).

Table 1. Operative Duration, Estimated Blood Loss, Approach, and Implant Selection for Patient Undergoing Total Hip Arthroplasty After Prior Peri-Acetabular Osteotomy

Operative Details	
Operative time (min)	66 (SD 16)
Estimated blood loss (ml)	285 (109)
Approach – n (%)	
Posterior	86 (76%)
Anterior	20 (17.7%)
Anterolateral	7 (6.2%)
Implants	
Fixation type	
Cup	100% cementless
Femur	96% cementless
Femoral stem geometry – n (%)	
Wedge Taper	81 (76%)
Conical	4 (3.7%)
Cylindrical	22 (21%)
Headball – n (%)	
Ceramic	81 (78%)
Cobalt Chrome	22 (21%)
Acetabular Liner –n (%)	
Polyethylene	100 (92%)
Ceramic	6 (5.5%)
Dual Mobility	3 (2.7%)
Radiographic cup position – degrees (SD)	
Abduction	40.8 (5)
Anteversion	28 (8.5)

DISCUSSION

Peri-acetabular osteotomy demonstrates a significant improvement in hip pain and function in patients with symptomatic hip dysplasia, but a significant portion of patients may ultimately undergo subsequent THA. As such, the outcomes of THA after PAO are vital to define, particularly for patients who may also be reasonable candidates for alternative procedures (i.e., isolated hip arthroscopy or arthroplasty). In this series of 113 hips with an average of 5-year follow-up, THA after PAO demonstrated excellent 5- and 10-year survivorship (96%) with significant improvement in hip-specific outcome scores. THA did not result in unexpectedly high blood loss, surgical duration, or rate of major complication. As such, prior PAO does not appear to compromise outcomes of subsequent THA in high-volume adult reconstruction surgeons.

Table 2. Complication Rates and Survivorship for Patients Undergoing Total Hip Arthroplasty After Peri-Acetabular Osteotomy

SURGICAL OUTCOMES		SD
Average follow-up (years)	5 (range 1-20)	4.0
MHHS improvement	37 points	18
Pre Op	50	15.7
Final follow up	87	14.3
Major complications – n (%)	8 (7.1%)	
Readmission for pneumonia	1 (0.88%)	
Periprosthetic femoral fracture	1 (0.88%)	
Wound dehiscence (requiring surgery)	1 (0.88%)	
Periprosthetic infection (?surgery)	1 (0.88%)	
Acetabular loosening	2 (1.77%)	
Revision for instability	1 (0.88%)	
Hip dislocation	1 (0.88%)	
Survivorship		
5 years	96%	
10 years	96%	
15 years	96%	

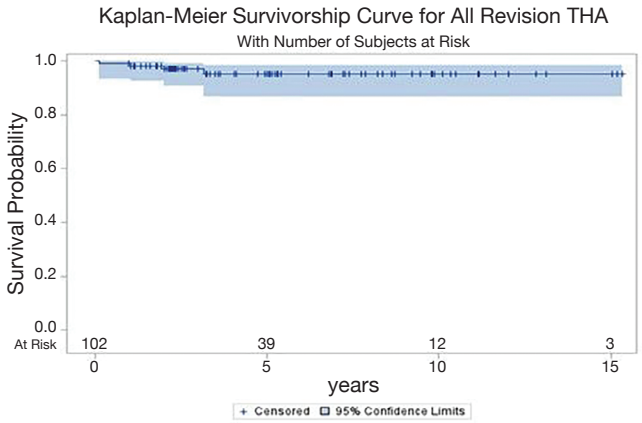

Figure 1. Kaplan-Meier survivorship curve for revision arthroplasty in patients undergoing total hip arthroplasty after prior peri-acetabular osteotomy.

Limitations of this study include the expertise bias which may be present, given all surgeons performing THA in this cohort work a tertiary care center and possess an interest in the management of hip dysplasia. However, these data do suggest favorable outcomes for THA after PAO, when performed by high-volume surgeons at tertiary care centers. Moreover, this study does not possess a control cohort for comparison, thus results can only detail the outcomes of arthroplasty in this select population rather than describe relative changes in complication profiles compared to other

populations. Finally, patients presented in this cohort received treatment over nearly three decades, during which the orthopaedic communities understanding of hip preservation and arthroplasty has significant evolved.

This study represents the largest cohort – to our knowledge – of patients undergoing THA following prior ipsilateral PAO and represents a significant addition to the relatively small (363 hips from 11 studies) body of literature available defining outcomes in this unique population.[17] In this cohort, the identified re-operation rate of 4%, lower than prior systematic reviews indicating a cumulative re-operation rate of 7.7% in patients undergoing total hip arthroplasty after any pelvic osteotomy for dysplasia.[17] Although not designed to directly compare survivorship or complication rates of our cohort to other populations, larger registry data indicates cumulative revision rates of 2-5% at 5 years in patients undergoing THA.[21] As such, prior PAO does not appear to significantly elevate an individual's risk for subsequent revision compared to the general population or patients undergoing THA in the setting of developmental dysplasia.[22]

Moreover, this data is in direct contrast to the marked increase in revision arthroplasty and complications (>10% at 2 years) in patients with prior isolated hip arthroscopy[23] or for patients undergoing total hip arthroplasty for patients with prior operative fixation of acetabular fractures.[24] The observed increase in revision THA after primary THA in setting of previous hip arthroscopy is unclear and deserves additional investigation. Given the increased interest in concurrent hip arthroscopy with PAO,[25] future consideration may be given to how intra-articular procedures combined with PAO may impact infection rate in patients undergoing subsequent THA. Acetabular fracture injury and fixation can result in distorted pelvic anatomy, retained hardware, heterotopic ossification, and associated neuromuscular compromise. These factors may very well impact THA outcomes after previous acetabular fracture treatment. In contrast, PAO acetabular fixation screws are commonly removed after healing and if retained usually do not require removal at the subsequent THA. As such, surgeons performing THA in this cohort may not have to contend with intra-operative removal of implants (i.e., periarticular fixation that interferes with cup placements) that may prolong operative duration and theoretically increase the risk of infection. Given the clear relationship between both hospital and surgeon surgical volumes and improved outcomes,[26] these results should be considered within the context of high volume surgeons at high volume centers.

Given alterations in acetabular anatomy after PAO, concerns exist that alterations in landmarks for cup placement may compromise acetabular cup position. Select prior publications have suggested that prior PAO may place individuals at risk for excessive abduction or retroversion of the acetabular component.[17] In this cohort, however, approximately 70% of acetabular components were placed within conventionally defined parameters and outliers were primarily related to increased acetabular anteversion. These outliers may be a consequence of numerous surgical factors: a significant percentage of hips performed from a posterior approach (where increase acetabular anteversion may be intentional), controversy regarding the ideal cup anteversion, degree of acetabular anteversion performed at time of index PAO or knowledge of pre-existing literature[27] detailing risk of acetabular retroversion in this patient population. Given only a single patient required a revision for instability, component position and instability do not appear to adversely affect outcomes of these hips. Additionally, in this study there were no acetabular grafts or augments in this relatively large cohort of dysplastic patients. This suggests that previous PAO does enhance acetabular bone stock for future THA and may alleviate the need for augmenting acetabular support. We would echo sentiments regarding the value of pre-operative planning and diligent intraoperative technique,[27] appropriate component placement can be reliably achieved in patient with prior PAO. Moreover, the increased availability of intra-operative robotics or navigation may assist surgeons in reliably positioning the acetabular component during THA in the setting of prior PAO.

CONCLUSION

THA after PAO achieves significant clinical improvement and satisfactory survivorship (96%) at mid-term follow-up, with a major complication of 7.1%.

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