Research Article

Ten- and 20-year Survivorship of the Hip After Periacetabular Osteotomy for Acetabular Dysplasia

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Abstract

Introduction: Acetabular dysplasia is a multifactorial condition characterized by a shallow hip socket with predisposition to osteoarthritis of the hip. The Bernese periacetabular osteotomy (PAO), developed by Reinhold Ganz in 1984, reorients the dysplastic hip joint to provide more uniform coverage of the femoral head and to extend the longevity of the native hip. Since 1987, the senior author performed the Bernese PAO on more than 430 patients. We performed a cross-sectional retrospective study on this cohort of patients to determine the 10- and 20-year survivorship after PAO in addition to assessing functional outcomes and radiographic parameters.

Methods: Four hundred thirty-four patients were treated for acetabular dysplasia with PAO by the senior surgeon from 1987 to 2014. Data were obtained for 302 hips in 258 patients in a retrospective fashion from medical records and/or mail-in/phone questionnaires. Functional outcome data consisted of postoperative Hip Osteoarthritis Outcome Score and University of California-Los Angeles Activity Score. Pre- and postoperative radiographs were used to determine lateral center-edge angle, anterior center-edge angle, Tönnis angle/grade, and head-to-ilioischial line distance. Survivorship of the native hip was determined by Kaplan-Meier analysis.

Results: Of the 302 hips analyzed, 248 were still surviving native hips and 54 had gone on to a total hip arthroplasty (THA) at the time of data acquisition. The average age of patients in the entire cohort at PAO was 32.7 years (range, 13 to 63 years). Of the 258 patients, 215 were female patients (83.3%) and 43 male patients (16.8%). The average age of patients in the surviving group at PAO was 32.3 years, and the average age of patients in the THA group was 36.6 years ($P < 0.01$). At the time of data acquisition, follow-up ranged from 2 to 27 years (average, 11.2 years). Hip Osteoarthritis Outcome Score and University of California-Los Angeles Activity Score are reported for the surviving native hips after PAO. Radiographic analyses for surviving and failed hips are described, with pre- and postoperative Tönnis grade being statistically significant predictors for conversion to THA ($P < 0.01$). Survivorship of the native hip was 86% at 10 years and 60% at 20 years in the surviving cohort. Survivorship stratified by age at the time of PAO demonstrated a 10-year survivorship of 93.3%, 90.1%, 81.6%, and 63.2% at ages 20, 30, 40, and 50 years, respectively. No notable difference exists in survivorship between male and female patients; however, male patients had a trend toward lower survivorship compared with female patients at 15 years.

Conclusion: The 10- and 20-year survivorship of the native hip after PAO is approximately 86% and 60%, respectively, in our cohort of 302 hips. Older age at the time of PAO and higher Tönnis grade are negative prognostic factors for joint survival after PAO. Surviving hips after PAO have good functional outcomes even up to 20 years after surgery. This survivorship analysis represents one of the largest and longest survival studies of patients after PAO, and our results are consistent with other published studies.

Level of Evidence: Level III

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Developmental dysplasia of the hip (DDH), also termed congenital dislocation of the hip, is a condition characterized by a shallow acetabulum, laxity of ligamentous structures about the hip, and possible abnormal proximal femoral morphology. It encompasses a wide spectrum of pathology ranging from fixed dislocation of the hip at birth to asymptomatic acetabular dysplasia in the adult.[1] We prefer to use the term DDH as opposed to congenital dislocation of the hip in the context of our outcome study. With an incidence of 1 in 1,000 in the United States,[2] it is the leading cause of end-stage osteoarthritis (OA) of the hip in patients younger than 50 years.[3]

DDH is a complex disorder with both environmental and genetic risk factors. Risk factors established for the development of DDH include female sex, breech delivery, family history, primiparity, large for gestational age, oligohydramnios, and genetics.[4] Epidemiologic and family study research has demonstrated that DDH likely involves an autosomal-dominant, polygenic type of inheritance; however, this research is still primitive and inconclusive. Most would agree, however, that genetics likely plays a role, because familial studies demonstrate a 12-fold increase in risk of DDH in first-degree relatives.[5] Monozygotic twins have a higher concordance of DDH than dizygotic twins—33% versus 8%.[6] Potential genes involved in DDH include single nucleotide polymorphisms of genes GDF5,[7] PAPPA2,[8] TBX4,[9] HOXD9,[10] and others. A study in one of the largest documented families with intergenerational DDH transmission revealed a damaging variant of the CX3CR1 chemokine receptor gene.[11] Another large multi-generation family study suggested possible gene linkage to a cluster of homeobox genes (HOX) on chromosome 17q21.32.[12]

Although DDH as an etiology of secondary OA of the hip varies by population, its presence is a known risk factor for OA and may be managed with a corrective osteotomy. A full discussion of the various osteotomies is beyond the scope of this article, and an excellent review has been discussed by Shibata et al.[13] However, we would like to briefly discuss the evolution of this procedure.

The temporal evolution of management of acetabular dysplasia is as follows: Shelf operation (Kong), acetabuloplasty (Pemberton, Dega), single osteotomy (Salter, Chiari), double osteotomy (Sutherland, Greenfield), triple osteotomy (LeCoeur, Hopf, and Steel), triple juxta-articular osteotomy (Tonnis, Carlios), spherical osteotomy (Wagner), dial osteotomy (Eppright), rotational osteotomy (Tagawa, Ninomiya), and Bernese periacetabular (Ganz). The treatment has evolved to focus on reorienting the acetabulum in three planes, allowing for medialization of a stable osteotomized fragment while not disrupting the blood supply. By performing a colored latex injection study, Beck et al[14] confirmed that the acetabular fragment blood supply (supra-acetabular and acetabular branches of the superior gluteal artery, the obturator artery, and the inferior gluteal artery) is maintained after a periacetabular osteotomy (PAO).

The senior author prefers the Bernese PAO over other procedures because it allows for more correction, allows for medialization compared with the non–periacetabular osteotomies (all but the spherical and juxta-articular), and maintains the blood supply. The Shelf procedure cannot mobilize the joint and can potentially damage the abductors. The Salter osteotomy hinges on the pubis and maintains the blood supply; however, it is limited to children younger than 6 years because of the level of dysplasia it can effectively treat. The double osteotomy is more invasive than the Salter osteotomy and allows for more medialization, but movability of the graft is limited, which limits the level of dysplasia it can treat. Although the Chiari osteotomy is safe and can mobilize the joint, it can limit hip range of motion, affects the abductors, and is considered a salvage procedure. Acetabuloplasty procedures are reserved for children and are performed by making an osteotomy above the acetabular roof and hinging it down while placing a graft above.

Compared with the juxta-articular osteotomy, the PAO is more stable with less pelvic ring deformity. The Bernese PAO allows for more medialization and maintains the blood supply compared with the spherical PAO. However, the Bernese PAO is limited by its technical difficulty and potential for complications if not properly performed.

The Bernese PAO was developed by Reinhold Ganz[15] in 1984 for management of adult DDH to improve deficient anterior and lateral coverage of the femoral head. This acetabular reorientation redistributes contact forces over a larger surface

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area with a subsequent decrease in contact pressures.[16] This change in biomechanics may be accompanied by biochemical changes in the cartilage matrix.[17] For instance, proteoglycan content is typically decreased in osteoarthritic cartilage and can be evaluated using delayed gadolinium-enhanced magnetic resonance imaging (dGEMRIC) of the cartilage. In the Hingsammer study,[17] proteoglycan content, assessed by dGEMRIC, was decreased at 1 and 2 years after PAO—especially at the superior acetabulum. The biochemical and clinical significance of this is yet to be determined. With a 30+ year history track record, a Bernese PAO joint-preserving procedure is preferred over arthroplasty in the younger population to preserve the longevity of the native hip.

In 1999, the senior author published an initial study on the outcomes after PAO at a minimum 2-year follow-up and demonstrated good-to-excellent results in 76% of patients.[18]

In this study, we determine the survivorship, functional results, and radiographic features of patients who underwent a PAO by the senior author dating back to 1987.

Methods

Preoperative Assessment

Four hundred thirty-four patients were treated for acetabular dysplasia by the senior surgeon between 1987 and 2014. Indications for surgery included greater than 6 months of pain in the involved hip, adequate range of motion, Tönnis grade 1 to 2 or less with some exceptions, lateral center-edge angle (LCEA) $<20°$, and closure of the triradiate cartilage. The indication for surgery became stricter with surgeon experience and will be further discussed in the discussion.

Initial radiographic evaluation included AP, false profile, and abduction/internal rotation views of the pelvis. Radiographic measurements included LCEA, head-to-ilioischial line distance (HIL) (measured from the lateral teardrop to the medial edge of the femoral head), and Tönnis angle/grade on the AP view. Anterior center-edge angle (ACEA) was measured on the false profile view. All radiographic analyses were performed in a blinded fashion.

Surgery

The operation was performed with the patient in the supine position on a radiolucent table. General anesthesia, preoperative antibiotics, and cell salvage were used routinely. The modified Smith-Petersen approach to the hip was performed via a conventional incision or an inguinal transverse incision. Osteotomies of the ischium, pubis, ilium, and posterior column were performed as described by Ganz et al.[15] A full description of the senior author's technique is described by Ziran et al.[19] Unlike Ganz, fluoroscopy was use, and acetabular reorientation was determined by the following: (1) horizontal or slightly undercorrected radiographic roof, (2) congruous femoral head under the radiographic roof, (3) adequate anterior/posterior acetabular coverage with acetabular anteversion, (4) medial displacement of the pubic portion of the acetabulum without loss of contact at the superior pubic ramus, (5) medialization of the femoral head, and (6) normal to near-normal Shenton line.

The average surgical time and estimated blood loss were approximately 1.5 hours and 500 mL, respectively. Postoperatively, patients were administered Coumadin, kept toe-touch weight-bearing for 6 weeks, and started physical therapy after 6 weeks to work on muscle strengthening and gait training. An AP pelvis radiograph and 45° oblique views of the pelvis were done on postoperative day 2. Follow-up radiographs were taken at 6 weeks, 12 weeks, 1 year, and 2 years, and 2-year intervals thereafter.

Postoperative Assessment

Functional outcome data consisted of the Hip Osteoarthritis Outcome Score (HOOS) and the University of California-Los Angeles (UCLA) Activity Score. The HOOS and UCLA Activity Score were collected by either telephone interview or mail-in questionnaire. Postoperative imaging included AP pelvic and false profile radiographic views.

Survivorship of the native hip was determined by Kaplan-Meier analysis using the SAS Statistical Program Package (SAS Institutes, version 9.3), with the clinical end point being total hip arthroplasty (THA). Other statistical comparisons and explorations were computed using SAS-GLM/analysis of variance for continuous measurements and chi-square or Fisher's exact test for discrete data. A P value of <0.05 was used to determine statistical significance.

The patients were categorized into the following cohorts based on their length of time at follow-up: zero to 5 years, 6 to 10 years, 11 to 15 years, 16 to 20 years, and >21 years.

Results

Of the 434 patients who underwent PAO, hip survivorship, HOOS, and UCLA Activity Score were obtained from 258 patients. Most of the patients for whom we could not obtain data had their surgery in the late 1980's or early 1990's. Patients in new locales with unavailable data were considered lost to follow-up. Three hundred two hips were evaluated in 258 patients. Of these, 215 were female patients and 43 male patients. The average age of patients at the time of PAO was 32.8 years (range, 13 to 63 years). The average postoperative follow-up was 11.2

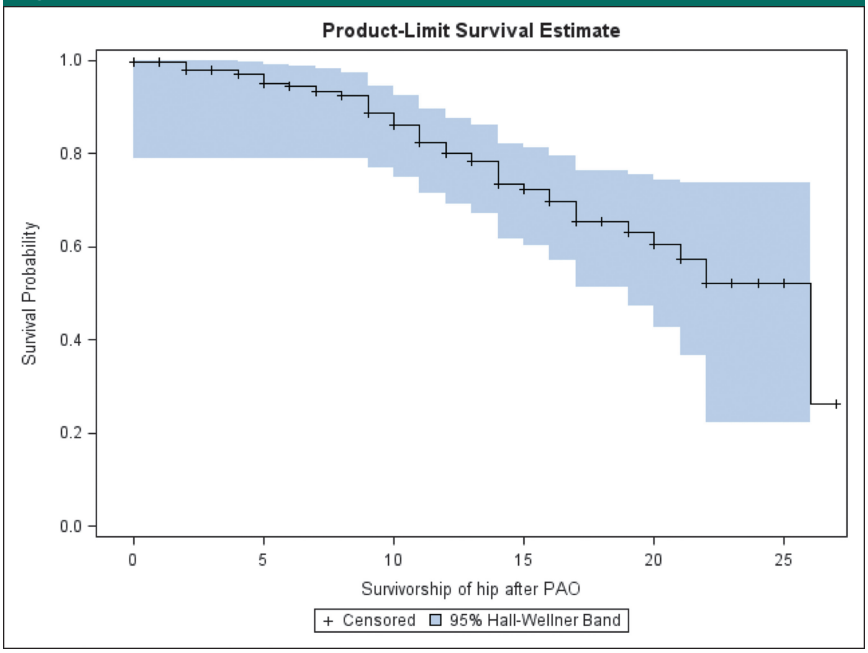
Table 1

Mean and SD of Functional Outcome Scores (HOOS/UCLA Activity Score) as a Function of Survivorship Year of Surviving Hips After Periacetabular Osteotomy

Survivorship (yr)	N (% Hips)	HOOS, Mean ± SD	UCLA Activity Score, Mean ± SD
0-5	100 (33.3)	80.9 ± 18.1	7.5 ± 2.2
6-10	83 (27.7)	81.8 ± 19.1	6.9 ± 2.1
11-15	64 (21.3)	74.4 ± 25.3	6.4 ± 2.1
16-20	35 (11.7)	75.6 ± 21.9	6.4 ± 2.1
21+	20 (6.6)	75.6 ± 21.9	6.4 ± 2.1

HOOS = Hip Osteoarthritis Outcome Score, UCLA = University of California-Los Angeles

Figure 1



Overall survival analysis of 302 hips after PAO. PAO = periacetabular osteotomy

years (range, 0.25 to 28.0 years). Patient characteristics are presented in Supplemental Table 1 (Supplemental Digital Content 1, http://links.lww.com/JAAOS/A203).

The HOOS and UCLA Activity Score for surviving hips after PAO are shown in Table 1. This patient cohort is young and active, and their functional scores decrease over time; we attributed this to a potential age-related decline. This decrease in UCLA Activity Score and HOOS seems to plateau around 10 years after surgery, but a statistically significant relationship does not exist.

Of the 302 hips analyzed, 248 were still surviving native hips and 54 had undergone THA at the time of data acquisition. The average age at the time of PAO was 32.3 years for surviving hips and 36.6 years for failed hips (THA) ($P < 0.01$) (Supplemental Table 2, Supplemental Digital Content 2, http://links.lww.com/JAAOS/A204).

Radiographic analyses of surviving and failed hips are shown in Table 3 (Supplemental Digital Content 2, http://links.lww.com/JAAOS/A204). Mean preoperative Tönnis grade was 0.16 in surviving hips and 0.47 in failed hips ($P < 0.01$). Mean postoperative Tönnis grade was 0.36 in surviving hips and 1.63 in failed hips ($P < 0.001$). The preoperative HIL was 9.1 for surviving hips and 5.2 for failed hips ($P < 0.05$). The postoperative HIL was 7.6 for surviving hips and 4.4 for failed hips ($P < 0.05$). No notable difference exists in pre- or postoperative Tönnis angle, LCEA, or ACEA between surviving and failed hips.

Kaplan-Meier analysis of the entire cohort is shown in Figure 1, with 86% survivorship of the native hip at 10 years and approximately 60% at 20 years. Survivorship stratified by age at PAO showed a 10-year survivorship of 93.3%, 90.1%, 81.6%, and 63.2% for ages 20, 30, 40, and 50, respectively ($P = 0.027$) (Figure 2).

No notable difference exists in survivorship between male and female patients at 10 years (Figure 3); however, male patients had a nonstatistically significant lower survivorship at 15 years compared with female patients. This lower survivorship was observed where the survivorship plotted lines crossed—an interaction may not have been picked up by Log-Rank or Wilcoxon analysis (Figure 3).

Of all hips, preoperative Tönnis grade was 81%, 16%, and 2% for Tönnis grade 0, 1, and 2, respectively. Survivorship at 10 and 20 years for preoperative Tönnis grade 0 hips was 88% and 56%, respectively, and is shown in Figure 4. Survivorship at 9 and 21 years for preoperative Tönnis grade 1 hips was 80% and 52%, respectively. Survivorship at 10 and 21 years for preoperative Tönnis grade 2 hips was 44% and 22%, respectively.

Postoperative Tönnis grade prevalence in observed survivorship

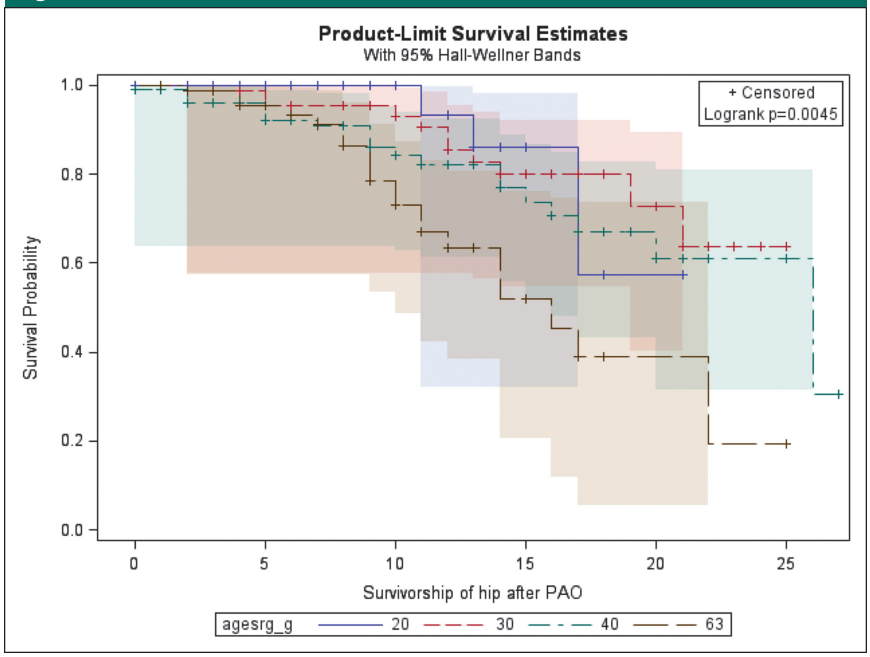
cohorts is shown in Table 2. The prevalence of Tönnis grade 2 and 3 hips increased the most between survivorship groups 16 to 20 and 21 to 30 years (13.4% and 14.3% increase in prevalence of Tönnis grades 2 and 3, respectively).

Discussion

Since the advent of the Ganz PAO, young patients with a painful hip resulting from acetabular dysplasia have a good option to improve their quality of life and increase the longevity of their native hip. The PAO was introduced over 30 years ago, and over this time, it has been shown to be an effective surgical treatment with good long-term results in preserving the native hip.[20] Our 10- and 20-year survivorship of the native hip after PAO was approximately 86% and 60%, respectively—these values are similar to results published by others. Our study had one of the longest follow-ups compared with other studies; however, a 30-year follow-up study of 75 patients after PAO reported a 29% survivorship.[21] Table 3 shows some of the largest and longest outcome PAO studies.

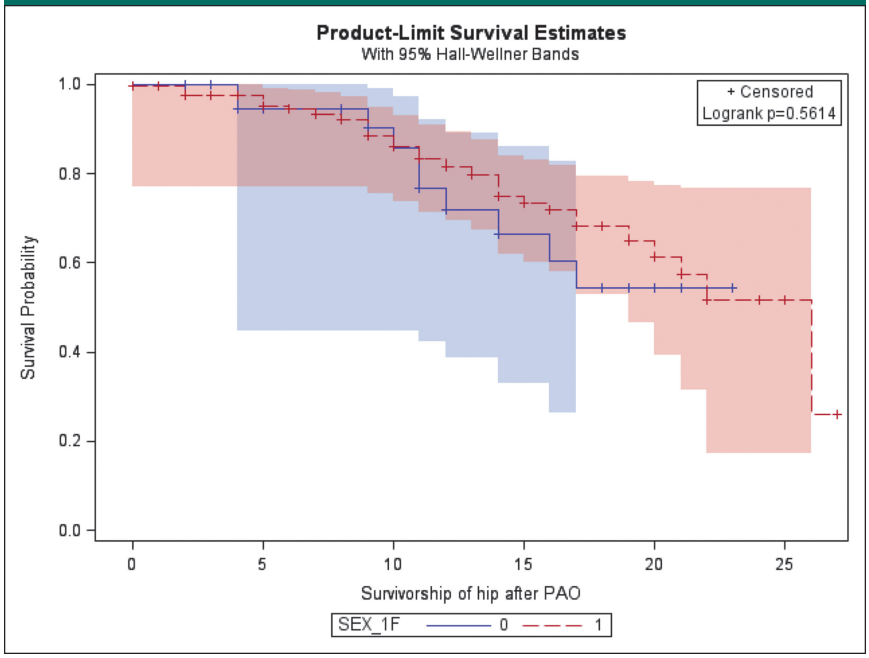
In our cohort, predictors for conversion to THA were more advanced OA (higher Tönnis grade) and increasing age, which have been described in previous studies.[18] Survivorship is higher in younger patients and in those with lower preoperative Tönnis grades (0 to 1). The average age at PAO for surviving and failed hips was 32.3 and 36.6 years, respectively. Overall, surviving hips had a statistically significant lower preoperative Tönnis grade (0.16) than failed hips (0.47). Tönnis grade 0 and 1 hips have approximately twice the survivorship of Tönnis grade 2 hips at 10 years. Survivorship drops off in patients who undergo PAO at age 40 years and above—10-year survivorship was 81.6% and 63.2% at ages 40 and 50 years, respectively, compared with 90.1% at age 30 years. This age-related decrease in survivorship should be taken into consideration

Figure 2



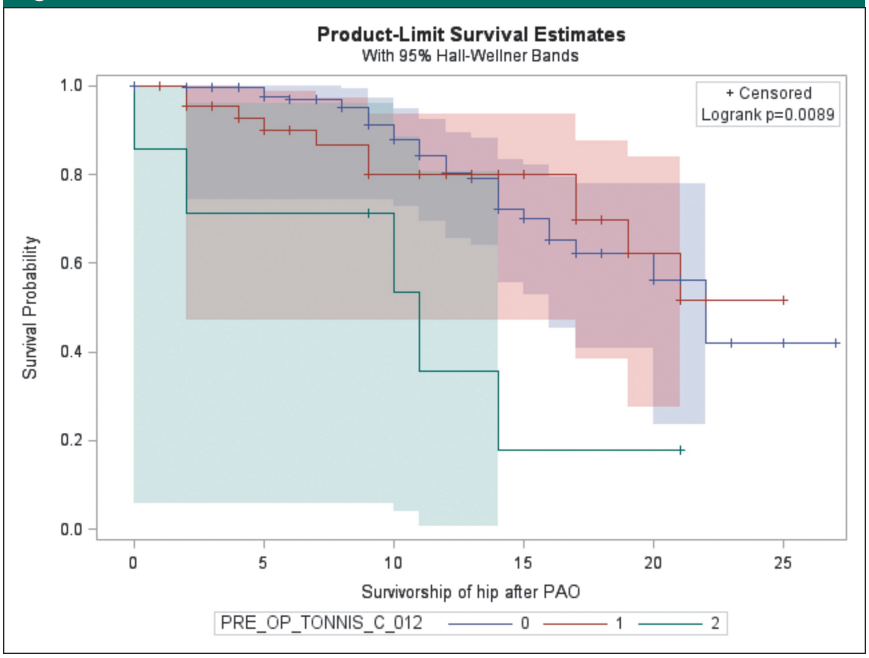
Survivorship of native hip after PAO (years) stratified by age group. PAO = periacetabular osteotomy

Figure 3



Survivorship of native hip after PAO (years) stratified by sex. PAO = periacetabular osteotomy

Figure 4



Survivorship of native hip after PAO (years) stratified by preoperative Tönnis grade. PAO = periacetabular osteotomy

during patient selection and preoperative education.

Postoperative Tönnis grade increases with time after PAO. The greatest increase in Tönnis grade 2 and 3 hip subcohorts occurred between the survivorship groups 16 to 20 and 21+ years after PAO. It is unclear whether this increase in prevalence in these cohorts is because of natural aging or survival of the joint after PAO.

We did not see a statistically significant relationship between preoperative LCEA, ACEA, and/or Tönnis angle in surviving versus failed hips. However, surviving hips had a statistically significant higher preoperative HIL distance than failed hips (9.1 versus 5.2). This result is surprising because we expected higher femoral head subluxation in prognostically worse hips. However, the SD of this entity was high in both the pre- and postoperative values, and there may have been some discrepancy in measurement techniques for this entity.

According to our data, female patients have a nonstatistically significant increase in survivorship compared with male patients; however, in our study, approximately five times more female patients than male patients were present. The analysis was performed by Log-Rank and Wilcoxon tests; and in cases where the survivorship lines cross, these analyses may not be able to pick up a significance even if one exists. The reasons for potential lower survivorship in male patients are unclear—whether it could be from higher activity or higher load in male patients.

The patients in our geographic region are educated and often have already researched the procedure and surgeons who perform it. In addition to providing them a pamphlet on the surgical procedure and postoperative course, we also provide them with 10- and 20-year survivorship data. This information helps our patients make an informed decision about surgery and may be particularly valuable for the active, physiologically young, dysplastic patient with a Tönnis grade 2 hip.

In the 1990s, some surgeons pushed the indications for a PAO by performing the procedure in more Tönnis grade 2 and 3 osteoarthritic

Table 2

Postoperative Tönnis Grade of Surviving Hip Cohorts

Observation Cohort of Surviving Hips (Years After PAO)	Post-op Tönnis Grade			
	0 No. of Hips/Total (%)	1 No. of Hips/Total (%)	2 No. of Hips/Total (%)	3 No. of Hips/Total (%)
0-5	70/85 (82.4)	14/85 (16.5)	—	1/85 (1.2)
6-10	52/68 (62.6)	14/68 (20.6)	2/68 (2.9)	—
11-15	27/46 (58.7)	18/46 (39.1)	1/46 (2.2)	—
16-20	12/25 (48.0)	11/25 (34.4)	2/25 (6.3)	—
21-30	3/14 (21.4)	6/14 (42.9)	3/14 (21.4)	2/14 (14.3)

PAO = periacetabular osteotomy

Table 3

Survival Outcome Studies After Periacetabular Osteotomy (Listed in the Order of Years Follow-up)

Author	Year	No. of Hips	Follow-up (yr)	Survivorship
Lerch et al[21]	2017	75	29.0	29% at 30 yr
Steppacher et al[20]	2008	68	20.4	87.6% at 10 yr and 60% at 20 yr
Albers et al[22]	2013	43	11.1	90.5% at 10 yr (optimal acetabular reorientation)
	—	122	11.1	78.6% at 10 yr (suboptimal acetabular reorientation)
Matheney et al[23]	2009	135	9	84% at 10 yr
Hartig-Andreasen et al[24]	2012	401	7.9	74.8% at 12.4 yr
Dahl et al[25]	2014	127	7	85% at 11.7 yr
Troelsen et al[26]	2009	116	6.8	81.6% at 9.2 yr

hips. Surgeons subsequently observed multiple failures after performing a PAO on Tönnis grade 2 and 3 hips after PAO and realized that in some cases this advanced degree of hip joint failure is not amenable to the procedure. There must be some degree of cartilage in the joint—the exact amount, and in which type of patient, remains unknown. The indications for the PAO are not necessarily discrete in some cases, that is, a Tönnis grade 1 to 2 hip in a chronologically older but physiologically younger, active patient. The senior author has seen some hips reverse their Tönnis grade after PAO. As mentioned before, biochemical changes occur in the cartilage matrix after the PAO. In the senior author's previous PAO outcome study on 66 hips, nine patients had radiographic improvement of the hip joint after surgery.[18] Some of these cases may represent radiographic hips with a falsely narrow joint space which were misread as a higher Tönnis grade. Very dysplastic hips can cause anterior subluxation of the femoral head; this subluxation can falsely narrow the superior joint space on an AP view by superimposing the top of the femoral head near the radiographic roof. Abduction-internal rotation radiographic views will show anticipated PAO correction and correct this "false" appearance of the superior joint space. Nevertheless, why some Tönnis grade 2 hips fail and others survive after a PAO is unknown but likely resulting from several factors such as surgical indications, genetics of cartilage matrix composition, surgical correction factors, and other comorbidities. We also had patients who, despite an uncomplicated PAO procedure with satisfactory correction, had rapid joint failure. Genetic analysis of potential genes involved in acetabular dysplasia (GDF5, PAPPA2, TBX4, HOXD9, CX3CR1, or homeobox genes) in these patients may demonstrate genetic predispositions to joint failure. Acetabular dysplasia has a polygenic inheritance that is complex and still evolving. However, the past decade of research has revealed promising results in linking acetabular dysplasia to genetic single nucleotide polymorphisms and variant genes. In addition to genetic testing, pre- and post-PAO MRI cartilage analysis (dGEMRIC) may also have demonstrated useful quantitative cartilage information in these patients.

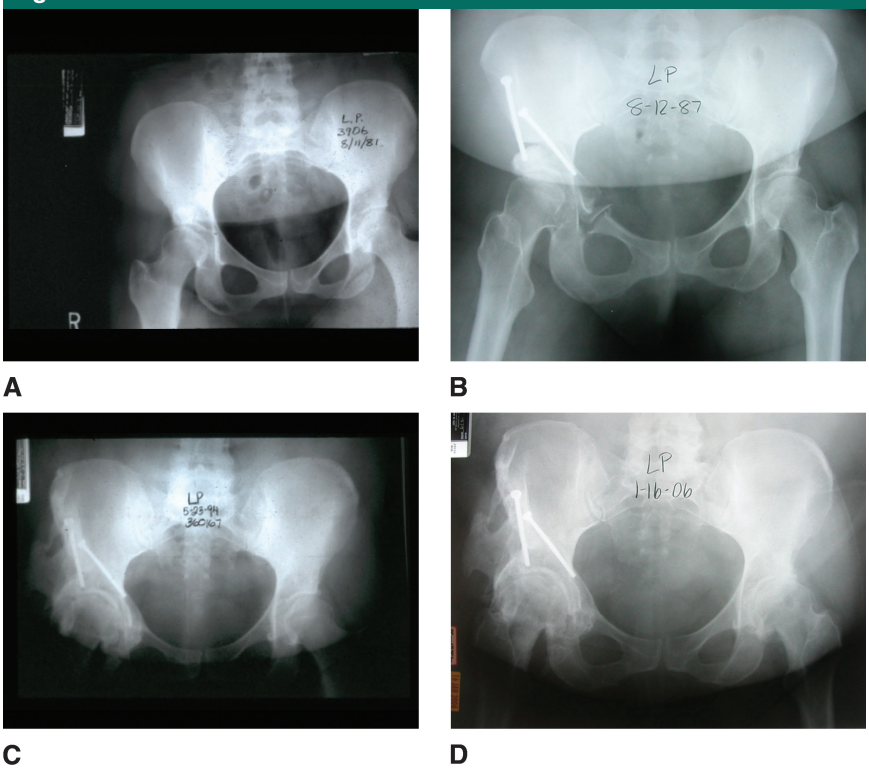
Despite what we still do not understand about acetabular dysplasia, the PAO, when performed with appropriate indications and proper technique, is an excellent hip joint-sparing surgery that can significantly improve quality of life. Figure 5 demonstrates a 32-year-old female patient with right > left acetabular dysplasia. She underwent a right hip PAO with maintenance of her right hip joint space for approximately 18.5 years. She presented with left hip pain and eventually underwent a left total hip replacement.

The limitations of our study include its retrospective design and the large number of patients lost to follow-up. As mentioned before, the bulk of the missing data was from patients who underwent the procedure between 20 and 30 years ago. The data from these patients would have been valuable because it represents a "subgroup" cohort with the longest follow-up. Despite this lost survivorship data, the Kaplan-Meier analysis estimate accounts for lost follow-up data, and our 10- and 20-year survivorship is consistent with other studies.

Another limitation of this study involves the role of surgeon experience and its relationship to clinical outcome. The PAO is a technically difficult procedure and surgeon experience may have played a role. We did not observe any statistical relationship between surgeon experience and survivorship; however, as mentioned before, some of these early data could not be obtained.

Last, of the older patients who underwent a PAO, a portion of this cohort may have needed a total hip replacement after 20 years, regardless—that is, it is unclear whether,

Figure 5



A B C D

AP pelvis radiographs of a 32-year-old female patient with right > left hip dysplasia pre- and post-PAO (**A** and **B**). The patient has a Tönnis grade 2 right hip. **C** and **D**, Demonstrate an AP pelvis radiograph approximately 7 and 18.5 years s/p right PAO, respectively. The patient had maintained her right hip superior joint space by 18.5 years and returned with left hip pain. PAO = periacetabular osteotomy

even if they were born with a "normal" hip, they would have required a total hip replacement at that age.

Recent studies have found a high incidence of labral tears, cartilage lesions, and soft-tissue disorders in dysplastic hip.[27-29] It is known that isolated hip arthroscopy to address labral pathology in these patients is rarely beneficial and may accelerate the arthritic process.[30] Some surgeons prefer to address labral pathology at the time of PAO.[31] It is the senior author's opinion that patients presenting with acetabular dysplasia and diagnosed labral tears do not need to have the hip opened for labral repair during PAO. The senior author's anecdotal experience with his cohort is that with redistribution of contact forces about the hip, the labrum is offloaded and heals on its own.

Of the patients who require a THA after PAO, the senior author's preferred method is the anterior approach. The distal portion of the modified Smith-Petersen incision can be used for the anterior approach. The tensor muscle may adhere to the overlying fascia and can be gently dissected using Metzenbaum scissors or an elevator. Furthermore, with the anterior approach, acetabular cup position, limb length, and offset are all quantifiable if fluoroscopy is used.

Last, the survivorship of a THA in young adults with DDH is similar to the survivorship of a PAO in our series. Swarup et al[32] demonstrated an 87% and 55% 10- and 20-year THA survivorship, respectively, in young adults (aged 35 years or below) with dysplastic hips. Given these similar survivorship values between a PAO and a THA in young patients with DDH, it is easier to perform a THA after a PAO than a revision THA in these young patients.

Conclusion

In experienced hands, the PAO extends the longevity of the native hip joint with an approximate 20-year survivorship of 60%. Younger patients and lower Tönnis grade are positive prognostic factors for patients after PAO. Patients who undergo a PAO at age 40 years or above have lower survivorship than younger patients. Male patients have a non-statistically significant decrease in native hip survivorship compared with female patients. The anterior approach is a good approach in patients who require a THA after PAO.

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