

# Trends, demographics and reoperation rates of periacetabular osteotomy: an analysis from the PearlDiver database

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## ABSTRACT

This study aims to examine the trends and demographics of periacetabular osteotomy (PAO) in the United States from 2016 to 2020 using a large healthcare database analysis. The PearlDiver database was queried for patients who underwent a PAO procedure starting with current procedural terminology (CPT) codes 27299, S2115 and 27146. Subsequently, the population was filtered for patients being ages 12–50, having an inpatient charge-type and those having a length of stay of at least 1 day. Patients with total hip arthroplasty were filtered out, and the resulting population was filtered by ICD-10 diagnosis codes. The providers of each patient were also examined to ensure their history of treating hip dysplasia. Student *t* and multiple regression analysis tests were used for statistical comparisons and trends analysis ( $P < 0.05$  reported as significant). A total of 535 consecutive patients were analyzed over the study period. There was a higher incidence of PAO in females compared with males ( $P < 0.001$ ) and a higher incidence of PAO in patients aged 15–19 years compared with older age groups ( $P = 0.017$ ). Within the first year after the index PAO, 171 of the 535 patients, almost one-third (32%), received a reoperation. Of the 171 reoperations, 115 were deep removal of implant, 55 were a hip arthroscopy and 1 patient had a bone excision for heterotopic ossification. Similar studies should be carried out using other large health databases to confirm the external validity of these trends and rates across the United States.

## INTRODUCTION

The Bernese periacetabular osteotomy (PAO), as described by Dr. Reinhold Ganz, is the standard of care for the treatment of hip dysplasia. The PAO is a reorienting osteotomy of the acetabulum that leaves the weight-bearing posterior column intact while adjusting the coverage of the femoral head, allowing the surgeon to change both version and inclination of the acetabulum [1]. The procedure is typically performed on patients who present with hip pain and radiographic findings of hip dysplasia [2] or acetabular retroversion [3, 4].

Several authors have demonstrated improvement in patient-reported hip pain and function following PAO surgery in short-, mid- and long-term follow-up studies [5–7], including those with severe deformity [8]. Further, with an increased understanding of both micro- and macro-instability of the hip joint [9, 10], abnormal acetabular morphology has become a prominent topic of interest in the hip preservation community. This has led to increased interest in the procedure clinically, yet the trends, demographics and reoperation rates following PAO surgery

remain largely unknown. To our knowledge, large database studies analyzing trends in PAO surgery have not yet been performed, perhaps owing to the difficulty of isolating the procedure using standard procedural coding.

The PearlDiver Mariner Patient Claims Database (PearlDiver Technologies, Colorado Springs, CO, USA) is a large US healthcare database that provides demographic information and longitudinally tracks patients with associated medical and procedural codes. This database includes claims of more than 151 million patients. The PearlDiver database contains International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9CM) and 10th Revision, Clinical Modification (ICD-10CM) codes, Current Procedural Terminology (CPT) codes and National Drug Codes (NDC). The database has been used to demonstrate trends over large populations of patients having certain procedures, but it has not yet been applied specifically to the PAO population.

This study aimed to examine the trends related to age, gender, region of the country and incidence of PAO procedures

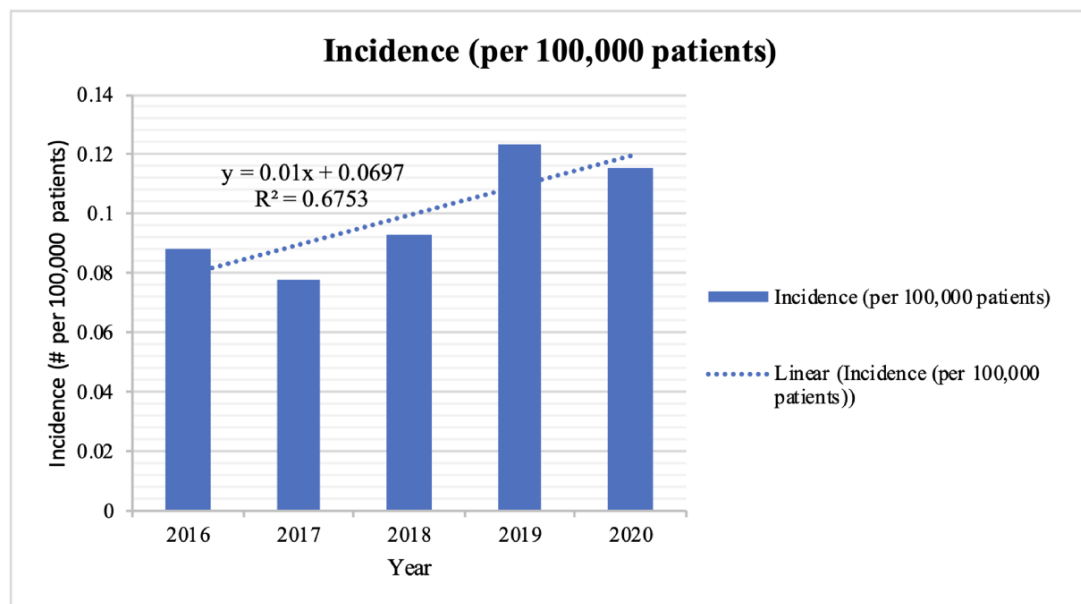


Fig. 1. Linear regression analysis in annual incidence of periacetabular osteotomy (PAO) per 100 000 patients.

performed in the United States from 2016 to 2020 using the PearlDiver database, propose a method for isolating PAOs in a database study and evaluate indications for reoperation over a heterogenous population.

## METHODS

The PearlDiver database was queried for patients who underwent a PAO procedure from 2016 to 2020, starting with CPT codes 27299 (unlisted procedure, pelvis or hip joint), 27146 (osteotomy, iliac, acetabular or innominate bone) and Healthcare Common Procedure Coding System (HCPCS) code S2115 (osteotomy, periacetabular, with internal fixation). S codes are unique temporary codes used for private payer systems and not yet adopted by Medicare.

Subsequently, the population was filtered for patients aged 12–50, with an inpatient charge, and those with a hospital stay of at least 1 day. Patients with total hip arthroplasty (THA) were excluded (CPT codes 27130, 27132, 27134, 27137, 27138), and the resulting population was filtered by ICD-10 diagnosis codes. The following ICD-10 codes were included: M16.2, M16.30, M16.31, M16.32, which represent osteoarthritis resulting from hip dysplasia, and Q65.1, Q65.2, Q65.89, Q65.00, Q65.01, Q65.02, which represent congenital dislocations of the hip. The providers of each patient were examined to ensure they have a history of treating hip dysplasia to improve internal validity of the data. Each provider was searched online, and it was confirmed that they indicated as part of their practice providing open treatment for hip dysplasia utilizing a PAO. If there was further question, we searched if the provider had written about PAOs and provided their own patients for case series, and finally, all providers were reviewed by the senior authors who have knowledge of this cohort of providers performing PAOs. Demographic data of year, sex, age and region were used to analyze trends in PAO. Furthermore, we evaluated which patients received a concurrent hip arthroscopy at the time of

PAO utilizing CPT codes: 29916 (labral repair), 29914 (femoro-plasty), 29862 (chondroplasty/labral resection), 29861 (loose body removal) and 29863 (synovectomy). Multiple regression analysis tests were used for trends analysis by year, age and region (Tables I, III and IV). A student *t*-test was used for statistical comparison of gender (Table II).  $P < 0.05$  was reported as significant. Regression analysis was performed to test for linear trends in the annual incidence of PAO per 100 000 patients over the study period (Fig. 1). In addition, reoperation rates were queried to determine which procedures were performed within the first year after a patient's index PAO.

## RESULTS

Over the study period, 535 consecutive patients were included for analysis. Although not statistically significant, there was a trend toward an increase in PAO procedures from 2016 to 2020 (Table I). There was a higher incidence of PAO in females compared with males ( $P < 0.001$ ), with 81.9% of the sample being female (Table II). There was a higher incidence of PAO in patients aged 15–19 years compared with other age groups ( $P = 0.017$ ) (Table III). There was no significant difference in the percentage of PAOs performed by region ( $P = 0.310$ ) (Table IV).

Of the 535 total PAO patients included for study, 164 (30.7%) had a concurrent hip arthroscopy at the time of PAO. Of those 164, 81 (49.4%) had a labral repair, 41 (25.0%) had a femoro-plasty, 16 (9.8%) had a chondroplasty/labral resection, 14 (8.5%) had a loose body removal and 12 (7.3%) had a synovectomy.

Within the first year after index PAO, 115 (21.5%) patients underwent deep removal of implant (CPT-20680), 55 (10.3%) underwent a hip arthroscopy and one patient (0.2%) had a bone excision for heterotopic ossification (HO). This totaled 171 of the 535 patients (32.0%) receiving a reoperation for any reason,

**Table I. Annual trends of periacetabular osteotomy (PAO) procedures performed from 2016 to 2020 in PearlDiver database, including compound annual growth rate**

Year	No. of PAO procedures	No. of patients in database	Incidence (per 100 000 patients)	Compound annual growth rate
2016	97	109 602 115	0.09	—
2017	85	109 613 296	0.08	−12.38%
2018	101	108 300 637	0.09	20.26%
2019	133	107 536 875	0.12	32.62%
2020	119	103 104 538	0.12	−6.68%
<b>Total</b>	<b>535</b>	<b>538 157 461</b>	<b>0.10</b>	<b>—</b>
<i>P</i> value	—	0.044	<b>0.071</b>	<b>—</b>

**Table II. Association of patient sex with incidence of periacetabular osteotomy (PAO) in PearlDiver database**

Sex	No. of PAO procedures	% of PAO procedures	% of PearlDiver population by sex	Incidence by sex (per 100 000 patients)
Female	438	81.9	57.5	0.50
Male	97	18.1	42.5	0.15
				<b><i>P</i> &lt; 0.001</b>

**Table III. Association of patient age with incidence of periacetabular osteotomy (PAO) in PearlDiver database**

Age, years	No. of PAO procedures	% of PAO procedures	% of PearlDiver population by age	Incidence by age (per 100 000 patients)
15–19	208	38.9	4.69	0.82
20–24	91	17.0	4.50	0.38
25–29	57	10.7	4.67	0.23
30–34	62	11.6	4.89	0.24
35–39	38	7.1	5.31	0.13
40–44	19	3.6	5.45	0.06
				<b><i>P</i> = 0.017</b>

**Table IV. Association of region with incidence of periacetabular osteotomy (PAO) in PearlDiver database**

Region	No. of PAO procedures	% of PAO procedures	% of PearlDiver population by region	Incidence by region (per 100 000 patients)
Midwest	271	50.7	22.53	0.22
Northeast	83	15.5	20.91	0.07
South	103	19.3	41.01	0.05
West	75	14.0	15.61	0.09
				<b><i>P</i> = 0.310</b>

but 115 out of 171 (67.2%) of these reoperations were for hardware removal which can sometimes be planned at the time of index procedure.

## DISCUSSION

In this study, by querying the PearlDiver database, one of the largest national health records databases in the United States, we observed trends in PAO surgeries being performed in the United States between 2016 and 2020. More specifically, of those undergoing PAO surgeries, there was a significant trend toward female predominance, and an increased percentage were younger in chronological age. Almost one-third of patients undergoing PAO surgeries received a subsequent reoperation within the first year. While most of these reoperations were for removal of deep implant, which can often be planned at the time of index surgery, a significant portion had a subsequent hip arthroscopy (10.3%).

And there was a trend toward significance in the number of PAOs performed between 2016 and 2020.

Hip dysplasia is more common in first-born and female patients, among other risk factors [11]. In an ultrasound study, female gender, even without risk factors of primiparity and family history, accounted for approximately 75% of dysplastic cases treated [12], roughly mirroring the percentage of PAOs represented by females in the current study. Despite widespread screening programs for hip dysplasia, several patients still escape detection until they present later in life with hip pain [13]. Fortunately, for those patients who escape detection by routine screening or do not present in early childhood, PAO surgery has been shown to be beneficial demonstrating great outcomes even out to 20 years post-operatively [6, 7].

Age at time of PAO is another interesting topic in the current literature. Some studies have reported greater risk of progression or failure with patients over the age of 35 or 40 [14]. Yet, recent

data from the ANCHOR group suggest that age may not be a great predictor of patient reported outcomes after surgery [15]. This is specifically important given the recent data in arthroplasty literature supporting the low wear rates of newer polyethylene implants at long-term follow-up [16], perhaps reassuring those who hesitated to perform THA in younger patients secondary to prior documented risks of increased wear and revision rates [17]. Nonetheless, for the reported years in the current study, most patients receiving PAOs are young with more than 50% under the age of 25 (Table III). As more studies begin to elucidate the performance of PAOs in older patients and THAs in younger patients, database studies may prove important in surveillance of outcome and secondary procedures.

In the current study, secondary procedures within the first year after PAO were common. Implant removal was the most common cause for reoperation, followed by hip arthroscopy and HO excision. Wyles *et al.* [18] reported a 13.6% rate of implant removal at an average of 1 year after PAO in their cohort, which is comparable to but less than the 21.5% rate demonstrated in our study. A systematic review by Clohisy *et al.* [2] found a range of 1–4% HO excision rate after PAO, and Cvetanovich *et al.* [19] noted a post-PAO rate of arthroscopy to be 3.1% in their study. The combined rate of 10.5% revision for arthroscopy and HO excision seems comparable to these reported rates. Importantly, zero patients underwent a THA within the first year following PAO in this study population. Using the PearlDiver database, we were able to delineate that 30.7% of patients received hip arthroscopy at the time of PAO, and there is a growing trend to perform these procedures together without changing the complication profile [20]. Currently, there is a multi-center randomized trial that is evaluating the outcomes of PAO with and without simultaneous hip arthroscopy [21]. Understanding institutional protocols for each patient included in the study regarding simultaneous versus staged hip arthroscopy would help shed light on the numbers of secondary hip arthroscopies recorded.

Large database studies are scarce with regard to the analyses of PAO surgery, with most studies reporting single surgeon or single institution experience [2, 6, 7]. This is perhaps owing to limitation of coding for PAO studies, with most suggesting to code using CPT code 27299 for unlisted procedure of the hip or pelvis [22]. Unfortunately, this code is catch-all for procedures and limits the simplistic use of the CPT code for database studies. With this study, using the PearlDiver database, we cross-referenced the CPT codes against those ICD codes that made sense as indications for PAO surgery, removed all arthroplasty codes and ensured the patients had at least 1 day overnight stay as inpatients in the hospital since most report 2- to 3-day hospital stays after PAO [23]. As a final check, we ensured by online research and review by our senior authors that all surgeons who had data included in the study are known to perform PAO surgery in the United States. With this method, we surmise that we had appropriately captured those PAO surgeries recorded in the database. With this information moving forward, it may be possible to perform large database studies evaluating trends in PAO surgery, at least until there is a separate CPT code specific to the operation.

The most notable limitation of the current study is the small number of cases included, which may limit the external validity of these findings. However, this data set does represent a

heterogeneous population across the United States and therefore mitigates regional or surgeon biases. PearlDiver is a resource that allows for large database studies regarding PAO. Until a CPT code is created for the procedure, the aforementioned method of isolating PAOs in the PearlDiver database is reasonable but may miss some cases in which the treating surgeon used a non-traditional billing technique. Unfortunately, due to the limitations inherent with ICD-10 coding and the lack of specificity associated with some of these diagnosis codes, it is difficult to ascertain with confidence the details associated with concurrent procedures, indication for PAO or complications. Moreover, we are unable to identify direction of acetabular correction with PAO procedures due to current CPT coding processes. Furthermore, it is difficult to differentiate whether a subsequent hip arthroscopy is performed on the same side due to a combination of CPT codes, HCPCS codes and ICD-10 diagnosis codes being used to filter our patient population. It is possible that a PAO performed on one side would subsequently list a contralateral hip arthroscopy as a possible reoperation. Further limitations of this study are those inherent to any large database study, specifically its retrospective nature, selection bias of included patients and inability to ascertain cause and effect relationships on reported trends.

## CONCLUSION

The available data for PAO procedures in the PearlDiver database, although a small subset of PAO procedures performed nationally, are a heterogeneous sample of patients from various surgeons that may help illustrate trends in open hip preservation surgery. Based on data available, there was a trend toward an increase in PAO procedures performed during the study period, with more surgeries being performed on females versus males and trend toward significance of PAO procedures performed in patients aged 15–19 years. Nearly one-third of PAO patients received a reoperation within the first year, typically for deep implant removal. Similar studies should be carried out using other large health databases to confirm the external validity and generalizability of these trends and rates across the United States.

## DATA AVAILABILITY

The data underlying this manuscript were obtained from a query of the PearlDiver Mariner Patient Claims Database and are available in this manuscript.

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