Comparison of the modified Smith-Petersen (S-P) and ilioinguinal (I-I) approaches for periacetabular osteotomy in adult developmental dysplasia of the hip: a retrospective study

Rui Luo

Guizhou Provincial People's Hospital

Li Guomin

Guizhou Provincial People's Hospital

Bing Li

Tianjin Hospital

Bo Li

Guizhou Provincial People's Hospital

Ruyin Hu (✉ lgm2018@yeah.net)

Guizhou Provincial People's Hospital

Jun Liu

Tianjin Hospital

Research article

Keywords: modified Smith-Petersen approach; ilioinguinal approach; periacetabular osteotomy; adult developmental dysplasia of the hip; retrospective study

Posted Date: July 30th, 2019

DOI: <https://doi.org/10.21203/rs.2.12096/v1>

License: This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Version of Record: A version of this preprint was published at Journal of Orthopaedic Surgery and Research on February 24th, 2021. See the published version at <https://doi.org/10.1186/s13018-021-02255-2>.

Abstract

Background Adult developmental dysplasia of the hip is an untreated congenital hip dysplasia that results in adult hip pain in adults. One of the usual and effective methods for the treatment of this condition is periacetabular osteotomy. However, controversy on which approach is better between the modified S-P and the I-I approaches is still unclear and ununified. Method and materials we retrospectively assessed our experience with the modified S-P and the I-I approaches by inquiring and evaluating of intraoperative blood loss, postoperative radiographic material, postoperative function of hip and related complications from July 2014 to January 2019. Results A total of 61 patients with adult developmental dysplasia of the hip were enrolled, and 33 patients were divided into group modified S-P and 28 patients were divided into group I-I. The operation time and blood loss of group I-I were higher than that of group modified S-P. other clinical and radiographic indexes showed no statistical significance between group modified S-P and group I-I. Conclusion There is no significant difference improving the function of the hip at the post-operation stage, but group I-I may require more operation time and blood loss at the intra-operation stage.

Introduction

Developmental dysplasia of the hip (DDH), or congenital hip dislocation (CDH), is a common abnormality in neonates with multiple abnormal morphological features such as the abnormal matching and inclusion between the acetabulum and the femoral head [1-2]. The etiology of DDH includes inheritance and intrauterine environmental factors, such as family genetic history, female gender, first child, hip delivery, oligohydramnios, torticollis, lower extremity deformities [3-4]. Most neonates With DDH can be diagnosed and treated at early age, however, a part of neonates born in the countryside or economically backward areas, do not carry out screening of DDH, and many patients with DDH visit orthopedics clinic in young adulthood [5].

Adult developmental dysplasia of the hip is an untreated congenital hip dysplasia that results in adult hip pain, and characterized by morphological anomalies of the hip joint that include acetabular dysplasia, decreased acetabular coverage of the femoral head, excessive femoral anteversion, an increased neck-shaft angle and a shortened femoral neck [6]. The incidence of adult developmental dysplasia of the hip is around 1 to 10%, and the male to female ratio approximates 1 in 6, with 25% of patients in the world having a family history of DDH [7]. In China, the incidence is remarkably lower than other countries, with about a percentage of 0.07 to 1.75‰, however, in the northern area, this percentage is higher than southern part [8].

These morphological abnormalities result in abnormal joint stress, that leads to subsequent labral tears and degradation of the articular cartilage; suggesting that the secondary hip osteoarthritis develops at an early age [9]. To correct the deficient and maloriented coverage of the femoral head, and to restore the normal mechanics of the hip, while relieving the pain of hip, one of the usual and effective methods of treatment is the periacetabular osteotomy (PAO), famously known as Bernese PAO, which was developed

in 1983 and first described by Ganz et al in 1988 [10]. Bernese PAO is a polygon-shaped juxta-articular osteotomy, which can obtain large corrections and in all directions, while protecting the sciatic nerve and permitting mobilization at early post-operation [11]. There are two surgical approaches that can be used in PAO: the I-I and the modified S-P approaches. Usually, most orthopedists prefer to use the modified S-P approach, since it has relatively lower rate of vascular and neural complications when compared to the I-I approach [12-14]. However, the controversy on approach is better between the modified S-P and the I-I approaches, is still unclear and ununified, this retrospective study aims at elaborating elaborate this controversy by comparing the modified S-P and the I-I approaches for periacetabular osteotomy in the adult developmental dysplasia of the hip.

Materials And Methods

Patients

This retrospective study was approved by the ethics committee of Guizhou Provincial People's Hospital. All periacetabular osteotomies were performed at our institution from July 2014 to January 2019. In this study, we retrospectively assessed our experience with the modified S-P and the I-I approaches by inquiring and evaluating intra-operative blood loss, post-operative radiographic material, post-operative function of the hip and relation complications. The modified S-P and the I-I approaches were used in successive time periods with no selection of patients, and all operations were performed by two senior orthopedicians.

Study design

The inclusion criteria were as follows: (1) diagnosed adult developmental dysplasia of the hip with painful acetabular dysplasia; (2) age 16-45 years; (3) with closed epiphyseal plates; (4) a center-edge (CE) angle of Wiberg of $< 25^\circ$; (5) maintained good range of motion; (6) Crowel I-III and no or early signs of osteoarthritis (Tönnis grade 0-II). The exclusion criteria were as follows: (1) procedures performed using other approaches; (2) incongruency between the femoral head and the acetabulum; (3) complete dislocation with a secondary acetabulum; (4) an advanced osteoarthritis (Tönnis grade $> II$)

Statistical analyses

All statistical analyses were performed by IBM SPSS Statistics 24. All the normally distributed data were presented as means with 95% confidence intervals (CIs) and the non-normally distributed data were presented as median with interquartile range. The independent sample t-test was used for continuous data in the clinical and radiographic outcomes between the two groups. Paired sample t-test was used evaluating changes between pre-operation and post-operation if the variance homogeneity detection is negative, and the Mann-Whitney U test was used for continuous data to pre-operative and post-operative differences in each group or in the same group if the variance homogeneity detection is positive. All binominal data in the two groups were calculated using Fisher's exact test. P-value less than 0.05 were considered statistically significant [15].

Results

Patients

A total of 61 patients with adult developmental dysplasia of the hip were enrolled in the study. The demographic data are shown in Table 1. According to different surgical approaches of PAO, 33 patients were divided into group modified S-P and 28 patients were divided into group I-I. Most patients were female, with the left hip longer than the right hip; however, there were no differences between the two groups in sex, age, side of the hip, weight, height, and BMI. The operation time and blood loss of the group I-I were higher than that of the group modified S-P (operation time: Mann Whitney U test, $p=0.000$; blood loss: 95%CI -659.47 to -287.19, $p=0.000$); and there were two patients who never strain in group modified S-P while there was one patient with incisional infection, and the other with a delayed wound healing in group I-I. there were no statistical differences between the two groups ($p=0.587$).

Clinical outcome between group modified S-P and group I-I

The mean function outcomes (poor, fair, medium, good, very good) were similar in the group modified S-P and group I-I at pre-operation and post-operation (pre-operation: $p=0.581$; post-operation: $p=0.992$). While comparing pre-operation and post-operation in each group, the function outcomes were remarkably improved (group modified S-P: $p=0.000$; group I-I: $p=0.000$). Meanwhile, the mean impingement test, the apprehension test, and the Trendelenburg sign were similar at pre-operation and post-operation. No statistical differences were observed, at pre-operation and post-operation, between the group modified S-P and the group I-I (pre-operation: impingement test- $p=0.810$, apprehension test- $p=0.449$, Trendelenburg sign- $p=0.737$; post-operation: impingement test- $p=0.379$, apprehension test- $p=0.621$, Trendelenburg sign- $p=0.569$), and all pre-operation incidence rates were notably lower than that of pre-operation in both groups ($p=0.000$).

The ROM of the hip includes flexion, extension, internal rotation, external rotation, abduction, and adduction. There were no evident discrepancy between the group modified S-P and the group I-I at pre-operation and post-operation. Although the degree of extension in the group I-I at pre-operation were bigger than that of the group modified S-P, and the degree of flexion in group modified S-P at post-operation were bigger than that of group I-I, the p values were statistically no significant (pre-operation: flexion- $p=0.289$, extension- $p=0.082$, internal rotation- $p=0.841$, external rotation- $p=0.250$, abduction- $p=0.718$, adduction- $p=0.578$; post-operation: flexion- $p=0.100$, extension- $p=0.470$, internal rotation- $p=0.332$, external rotation- $p=0.728$, abduction- $p=0.592$, adduction- $p=0.428$). In the group modified S-P, the ROM of flexion, extension, and adduction had remarkable changes after operation (flexion: $p=0.016$; extension: $p=0.030$; adduction: $p=0.000$), the ROM of internal rotation, external rotation and abduction were also changed, but the outcomes were not statistically significant (internal rotation: $p=0.424$; external rotation: $p=0.748$; abduction: $p=0.233$). In the group I-I, all ROM degrees had changes, but only the degree of flexion, abduction, and adduction were statistically significant (flexion: $p=0.002$; extension: $p=0.076$; internal rotation: $p=0.092$; external rotation: $p=0.074$; abduction: $p=0.027$; adduction: $p=0.000$). All clinical data were shown in Table 2 and Table 3.

Radiographic differences between the group modified S-P and the group I-I

According to clinical data, all the DDH indexes were similar between the groups in pre-operation and post-operation except a sharp angle in pre-operation ($p=0.007$). Compared with pre-operation, the total femoral coverage, the anterior center-edge angle, the lateral the center-edge angle, the sharp angle and the acetabular index were remarkably improved to the normal value of the hip. Meanwhile, Shenton's line intact and Calvé's line intact were consecutive and smooth lines in post-operation and in all cases. In both group modified S-P and group I-I, the positive incidence of the crossover sign, in post-operation was significantly lower than the one in pre-operation (all of p value were 0.000), and there was no significant difference between the groups (pre-operation: $p=0.600$; post-operation: $p=0.463$).

Discussion

Periacetabular osteotomy is an effective way to rebuild the acetabular structure, relief the pain after movement and improve the movement function of the hip. In general, patients whose age ranges from ten years to fifty years, that showed a reduced pain and normal movement function of the hip, a healed acetabular callus line, a good relationship between the head and the acetabular and a none or mild osteoarthritis are proper indication for PAO. On the contrary, if a patient was much younger or older, or with poor movement function of hip, or poor relationship between the head and the acetabular, or serious osteoarthritis, the outcome of PAO is poor, and therefore its application is counter indicated [16]. Recently, the ilioinguinal, the Smith-Petersen, and the minimally invasive transsartorial approached were usually used to perform the periacetabular osteotomy surgery; that is a new and relatively safe approach, with minimally invasive transsartorial that can reduce surgical trauma, blood loss, and the duration of surgery. Although more orthopedists consider the minimally invasive transsartorial approach safer than other approaches, it is difficult to perform PAO surgery since the incision is relatively smaller. However, there are some studies that compare the outcome between the among ilioinguinal, the Smith-Petersen, and the minimally invasive transsartorial approaches [17-20].

In adult developmental dysplasia of the hip, the abnormal femoral head and acetabular structure, the hip range-of-motion containing flexion, extension, external rotation, internal rotation, abduction, adduction, are inconsistent in normal people. For example, the degree of extension and internal rotation is larger than the normal value, even it is hard to correct to normal degree after rotational acetabular osteotomy (RAO) or periacetabular osteotomy (PAO) surgery [21-22]. In our study, the hip range-of-motion is a huge discrepancy in healthy people, as the degree of abduction motion is smaller and the degree of adduction motion is obviously larger than in healthy people.

In patients with DDH, as the acetabular dysplasia and the total femoral coverage are lower, with the femoral head leading to shift toward and above the acetabulum leading to luxation and hip instability. It is difficult to determine the center of the hip since the abnormal structure of hip; it may cause a little deviation when we measure the angle on an image map especially with the lateral center-edge and the anterior center-edge angles [23]. Meanwhile, most patients with DDH have bilateral leg length discrepancy

leading that leads to pelvic tilt, that affects the limitless of the technology of taking image maps, causes interference and influences the measuring of angles and indexes of the hip, finally leading to the deviation of results analysis by drawing inaccurate conclusions [24]. In the post-PAO surgery image map, the anatomical sign of acetabular is not obvious or difficult to determine. Radiographic data, in both group modified S-P and group I-I, may result into errors, that influence the final results of the analysis. In our study, we invited three researchers to analyze the radiographic data, and in case of inconsistent results, we discussed the results until drawing same conclusions, or if the disagreement persisted, we sought advise from senior doctors.

Comparing to total hip arthroplasty, periacetabular osteotomy surgery has a higher incidence of complications. As in the front and rear of the acetabular are respectively found the femoral nerve and the sciatic never, PAO surgery is more inclined to injure the nerve and blood vessels that surround the acetabular causing abnormal motion and feeling. The pelvis has a rich blood supply and PAO has a large damage range that can cause interoperation blood loss in most patients, and which would require blood transfusion to restore blood volume. At the same time, acetabular coverage may be incomplete or excessive leading to unsatisfactory function recovery if no sufficient preparation during pre-operation [25-27]. In our study, as the incision was long and deep using the ilioinguinal approach, the patient easily acquires an incisional infection; while the surrounding nerve may be pulled by the modified Smith-Petersen approach due to the relatively small incision.

Although periacetabular osteotomy was used to cure adult developmental dysplasia of the hip for many years, the best approach to use among the ilioinguinal, the Smith-Petersen and the minimally invasive transsartorial approaches is unclear. In our study, we draw a conclusion that there is no significant difference in the improvement of the function of hip at post-operation, but group I-I may take more operation time and more loss of blood in intra-operation. However, there are still several limits. Firstly, this paper is a retrospective study, with many factors that may interfere with the results of the analysis; secondly, the number of patients is smaller, and therefore there is a need to increase the sample size; and finally, our study is a single center study, and we need several hospitals to join the study in order to draw a more accurate conclusion in the future.

In conclusion, the periacetabular osteotomy is an effective way to correct adult developmental dysplasia of the hip, whether using the modified Smith-Petersen (S-P) or the ilioinguinal (I-I) approaches. There is no significant difference in the improvement of the function of the hip at post-operation, but group I-I may take more operation time and loss of blood in intra-operation.

Declarations

Source of funding

Guizhou Provincial Traditional Chinese Medicine and Ethnic Medicine Science and Technology Fund
QZYY2017-103; Tianjin Health and Family Planning Commission Science and Technology Fund Key
Project 14KG123; Tianjin Natural Science Foundation 17JCQNJC11800; Tianjin Science and

Technology Support Project (18YFZCSY00890); Tianjin Biomedical Engineering Technology Key Project (18ZXSGSY00010).

Conflict of Interest Statement

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patentcensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

Ethical Review Committee Statement

Manuscripts involving humans or human data have been accompanied by a copy of the letter from ethical committee approving in our study.

References

1. Noordin S, Umer M, Hafeez K, et al. (2010) Developmental dysplasia of the hip[J]. Orthop Rev, 2(2):e19.
2. Bracken J, Tran T, (2012) Ditchfield M. Developmental dysplasia of the hip: controversies and current concepts[J]. Journal of Paediatrics & Child Health, 48(11):963-973.
3. Noble P C, Kamaric E, Sugano N, et al. (2003) Three-dimensional shape of the dysplastic femur: implications for THR[J]. Clin Orthop, 417(417):27-40.
4. Albinana J, Dolan L A, Spratt K F, et al. (2005) Acetabular dysplasia after treatment for developmental dysplasia of the hip[J]. Journal of Bone & Joint Surgery-british Volume, 86(6):876-886.
5. Dezateux C, Rosendahl K. (2007) Developmental dysplasia of the hip[J]. The Lancet, 369(9572): 1541-1552.
6. Sugano N, Noble P C, Kamaric E, et al. (1998) The morphology of the femur in developmental dysplasia of the hip[J]. The Journal of bone and joint surgery. British volume, 80(4): 711-719.
7. Schuster W. (1978) Radiologic interpretation of dysplasia of the acetabulum[M]//Acetabular dysplasia. Springer, Berlin, Heidelberg, 1978:73-84.
8. Shijun Ji, Yongde Zhou. (1994) Clinical and research of congenital dislocation of the hip [M]. Shenyang: Shenyang Publishing House, 2014:15-21.
9. Sampson T G. (2005) Hip morphology and its relationship to pathology: Dyplasia to impingement[J]. Operative Techniques in Sports Medicine, 13(1):37-45.
10. Ganz R, Klaue K A J, Vinh T S, et al. (1988) A new periacetabular osteotomy for the treatment of hip dysplasias technique and preliminary results[J]. Clinical Orthopaedics and Related Research®, 232: 26-36.

11. Munro J T, Graydon A J, Garbuz D S. (2014) Pelvic Osteotomy for Young Adult Hip Disease[M]//The Young Adult Hip in Sport. Springer, London, 2014: 249-262.
12. MacDonald S J, Hersche O, Rodriguez J, et al. (1997) The Bernese periacetabular osteotomy for the treatment of adult hip dysplasia[J]. La Chirurgia degli organi di movimento, 82(2): 143-154.
13. Leunig M, Siebenrock K A, Ganz R. (2001) Rationale of periacetabular osteotomy and background work[J]. JBJS, 83(3): 438-448.
14. Letournel E. (1993) The treatment of acetabular fractures through the ilioinguinal approach[J]. Clinical orthopaedics and related research, 292: 62-76.
15. Amrhein V, Korner-Nievergelt F, Roth T. (2017) The earth is flat ($p > 0.05$): significance thresholds and the crisis of unreplicable research[J]. PeerJ, 5: e3544.
16. Yasunaga Y, Yamasaki T, Ochi M. (2012) Patient selection criteria for periacetabular osteotomy or rotational acetabular osteotomy[J]. Clinical Orthopaedics and Related Research®, 470(12): 3342-3354.
17. Troelsen A, Elmengaard B, Søballe K. (2008) A new minimally invasive transsartorial approach for periacetabular osteotomy[J]. JBJS, 90(3): 493-498.
18. Troelsen A, Elmengaard B, Søballe K. (2008) Comparison of the minimally invasive and ilioinguinal approaches for periacetabular osteotomy 263 single-surgeon procedures in well-defined study groups[J]. Acta orthopaedica, 79(6): 777-784.
19. Troelsen A, Elmengaard B, Søballe K. (2008) A new minimally invasive transsartorial approach for periacetabular osteotomy[J]. JBJS, 90(3): 493-498.
20. Mechlenburg I, Dugaard H, Søballe K. (2009) Radiation exposure to the orthopaedic surgeon during periacetabular osteotomy[J]. International orthopaedics, 33(6): 1747.
21. Hamada H, Takao M, Nakahara I, et al. (2016) Hip range-of-motion (ROM) is less than normal after rotational acetabular osteotomy for developmental dysplasia of the hip: A simulated ROM analysis[J]. Journal of Orthopaedic Research, 34(2): 217-223.
22. Ganz R, Horowitz K, Leunig M. (2010) Algorithm for femoral and periacetabular osteotomies in complex hip deformities[J]. Clinical Orthopaedics and Related Research®, 468(12): 3168-3180.
23. Nakamura S, Yorikawa J, Otsuka K, et al. (2000) Evaluation of acetabular dysplasia using a top view of the hip on three-dimensional CT[J]. Journal of orthopaedic science, 5(6): 533-539.
24. Argenson J N, Ryembault E, Flecher X, et al. (2005) Three-dimensional anatomy of the hip in osteoarthritis after developmental dysplasia[J]. The Journal of bone and joint surgery. British volume, 87(9): 1192-1196.
25. Hussell J G, Rodriguez J A, Ganz R. (1999) Technical complications of the Bernese periacetabular osteotomy[J]. Clinical orthopaedics and related research, 363: 81-92.
26. Trousdale R, Cabanela M. (2003) Lessons learned after more than 250 periacetabular osteotomies[J]. Acta Orthopaedica Scandinavica, 74(2): 119-126.

27. Davey J P , Santore R F . (1999) Complications of Periacetabular Osteotomy[J]. Clinical Orthopaedics and Related Research, 363(363):33-37.

Figures

Figure 1: Magnetic resonance images of the hip of a patient with DDH, A: T2 and coronal plane; B: T2 and transverse plane; C and D: T1 and transverse plane.

Figure 1

Magnetic resonance images of the hip of a patient with DDH, A: T2 and coronal plane; B: T2 and transverse plane; C and D: T1 and transverse plane.

Figure 2: Radiographic images of the hip at pre-operation and post-operation, A-E: double lower limb length, pelvic positive position, left hip joint 65° oblique piece, right hip joint 65° oblique piece at pre-operation; F-I: pelvic positive position, left hip joint 65° oblique piece, right hip joint 65° oblique piece at post-operation.

Figure 2

Radiographic images of the hip at pre-operation and post-operation, A-E: double lower limb length, pelvic positive position, left hip joint 65° oblique piece, right hip joint 65° oblique piece at pre-operation; F-I: pelvic positive position, left hip joint 65° oblique piece, right hip joint 65° oblique piece at post-operation.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Tables.pdf](#)