■ HIP

The Birmingham Interlocking Pelvic Osteotomy for acetabular dysplasia

13- TO 21-YEAR SURVIVAL OUTCOMES

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Aims
The aim of this study was to evaluate the long-term clinical and radiographic outcomes of the Birmingham Interlocking Pelvic Osteotomy (BIPO).

Patients and Methods
In this prospective study, we report the mid- to long-term clinical outcomes of the first 100 consecutive patients (116 hips; 88 in women, 28 in men) undergoing BIPO, reflecting the surgeon's learning curve. Failure was defined as conversion to hip arthroplasty. The mean age at operation was 31 years (7 to 57). Three patients (three hips) were lost to follow-up.

Results
Survivorship was 76% at ten years and 57% at a mean of 17 years. Younger patients (< 20 years) had the best survivorship (20 hips at risk; 90% at 17 years; 95% confidence interval 65 to 97). Post-operative complications occurred after 12 operations (10.4%) over the duration of the study. Increasing patient age and hip arthritis grade were primary determinants of surgical failure.

Conclusion
BIPO provides good to excellent survivorship in appropriately selected patients, with a relatively low rate of complications. Our results are comparable with other established methods of periacetabular osteotomy (PAO), such as the Bernese PAO, even during the surgeon's initial learning curve.

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Acetabular dysplasia is characterised by deficient superior and anterior coverage of the femoral head, which is associated with reduced acetabular depth and lateralisation of the femoral head.[1] The increased force applied to the anterolateral acetabular rim leads to labral hypertrophy, labral tears and progressive degeneration of the marginal articular cartilage.[2,3] Left untreated, symptomatic acetabular dysplasia may precipitate early-onset osteoarthritis of the hip,[1,4,5] which might necessitate total hip arthroplasty at a young age.

As arthroplasty in young active patients is likely to require at least one revision during the patient's lifetime,[6,7] the onus is on the surgeon to keep the native hip functional for as long as possible. Whereas each revision arthroplasty is accompanied by increasing risks and deteriorating outcomes, a successful reorientation osteotomy has been shown to reduce pain,[8] improve joint stability, and delay the development of osteoarthritis.[9-11] If conversion to arthroplasty is required, a prior realignment procedure can also improve acetabular component fixation.[12,13]

The goals of pelvic osteotomy are to provide a pain-free hip joint and enable pre-injury levels of activity. The ideal technique should be accurate, reproducible, and have a low rate of complications. Several pelvic osteotomies to correct acetabular dysplasia have been described in the literature,[14-16] including the triple osteotomy developed by Tönnis et al[17] and the Bernese periacetabular osteotomy (PAO) developed by Ganz et al.[15] Despite allowing unimpaired acetabular correction, these osteotomies do not provide sufficient intrinsic stability to allow immediate weight-bearing and rapid rehabilitation. Moreover, the Bernese osteotomy is technically demanding and has a relatively high complication rate, especially during the surgeon's learning curve.[18,19]

The Birmingham Interlocking Pelvic Osteotomy (BIPO) represents a novel form of triple osteotomy that addresses several shortcomings of the previously described methods.[14,17-19] The BIPO technique aims to improve the safety, accuracy, and reproducibility of correcting

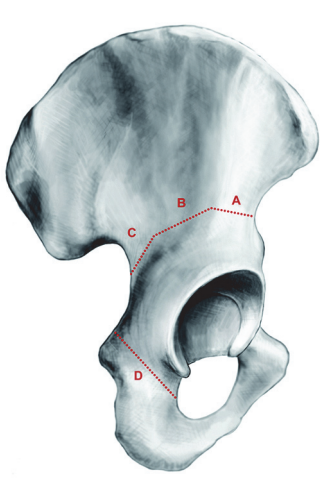

Fig. 1a

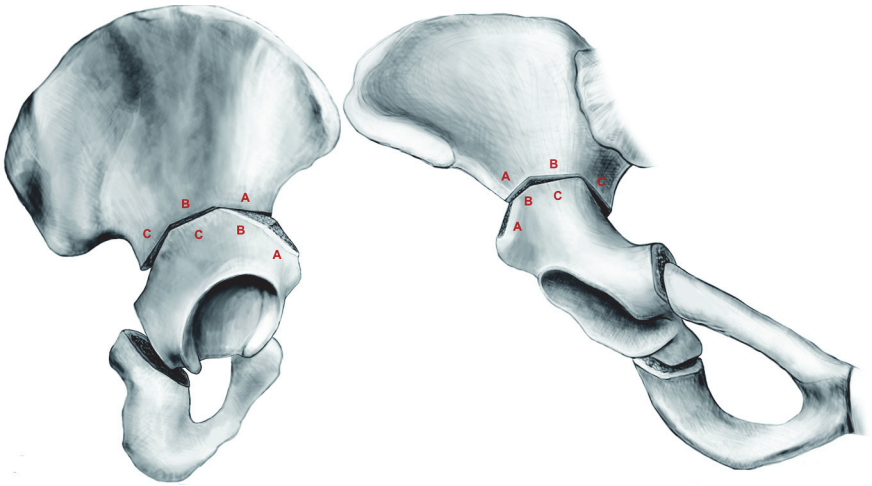

Fig. 1b

Schematic diagrams showing a) Birmingham Interlocking Pelvic Osteotomy (BIPO) demonstrating location of iliac bony cuts (A, B, and C) and ischial cut (D) and b) schematic diagram of the BIPO demonstrating repositioned central acetabular fragment with interlocking iliac cut.

acetabular malalignment in dysplasia. Furthermore, through an inherently more stable interlocking correction, BIPO permits unrestricted post-operative weight-bearing and faster functional recovery. The volume and size of the central acetabular fragment created by this technique is similar to the Bernese PAO.[15] This prospective study identifies mid- to long-term clinical and functional outcomes in a consecutive series of the first 100 patients undergoing treatment by BIPO, representing the developing surgeon's (JNO-H) initial experience.

Patients and Methods

Following Institutional Review Board approval, we retrospectively analysed prospectively collected data from a consecutive cohort of the first 100 patients treated by BIPO for symptomatic acetabular dysplasia between January 1992 and June 2000. All procedures were performed by the senior hip preservation surgeon who developed this technique (JNO-H) at a single institution, reflecting the initial learning curve. A total of 116 BIPO procedures (100 patients) were performed. Of these, 88 procedures were performed on women and 28 on men. There were 60 left hips and 56 right hips. The mean age was 31 years (7 to 57) at operation. Four of these patients had teratological hip dysplasia: two had mild diplegic cerebral palsy, one had Down syndrome, and one had post-polio syndrome. None had any prior treatment.

The inclusion criteria for operation included hip pain for a minimum of six months having failed conservative management; a lateral centre-edge (LCE) angle < 25°,[20] a sourcil angle[21] > 10°, or an interruption of Shenton's line; and a range of movement of the hip sufficient to allow rotation of the acetabulum to produce a congruent joint without impingement. The range of movement and planned correction was confirmed at pre-operative examination-under-anaesthesia with image intensifier. We excluded patients with radiographic evidence of osteoarthritis (Tönnis grade > II[1,22]), body mass index > 40 kg/m^2, or previous hip surgery. Patients selected for surgery had pre-operative CT and/or MRI scans to assess acetabular version and femoral head sphericity. Patients with femoral head exosphericity > 2 mm (measured at maximal femoral head diameter on the CT scans)[23] or pistol-grip deformity were excluded from the study.

Surgical technique. The operation was performed as described by Kumar et al.[24] Briefly, pre-operative planning involved measurement of the acetabular deformity on a standardised series of plain radiographs including an anteroposterior (AP) pelvic and an abduction view for congruency, and CT scans in order to define accurately, in three planes, the presenting deformity and malalignment. The goal of surgical intervention was to correct the acetabular sourcil to within 10° of the horizontal, with zero cranial anteversion (apical acetabular version was measured on a single axial CT image) and an LCE > 25°. The BIPO technique is divided into two stages: In the first stage, the ischial osteotomy is performed (in the lateral position) through a mini-incision posterior approach. After longitudinally separating the gluteus maximus fibres and mobilising the sciatic nerve proximally, as far as the sciatic notch and distally as far as the gluteus maximus insertion, it is moved posteriorly away from the field. The interval between the short external rotators is established, followed by the use of a 2.5 cm lexer osteotome to perform the ischial osteotomy from the greater sciatic notch to the obturator foramen. In the second stage, an anterior skin incision similar to that used in the Bernese PAO is made to access the ilium and pubis. The next bony cut is of the superior pubic ramus, just medial to the quadrilateral plate, achieving a large apposition surface to promote bony healing. Finally, three interconnected iliac

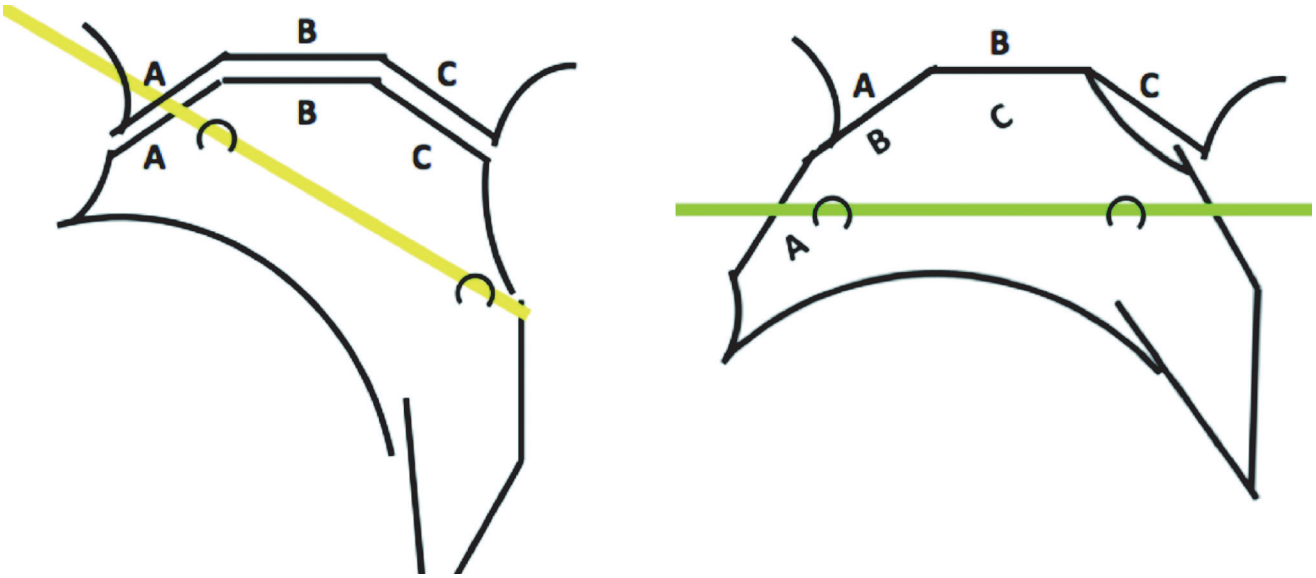

Fig. 2

Schematic diagram showing the orientation of external fixator pin holes before (left) and after (right) bony realignment. On executing the planned correction for lateral coverage, the holes become aligned in the horizontal plane giving intra-operative visual confirmation (A, B, C represent location of iliac bony cuts).

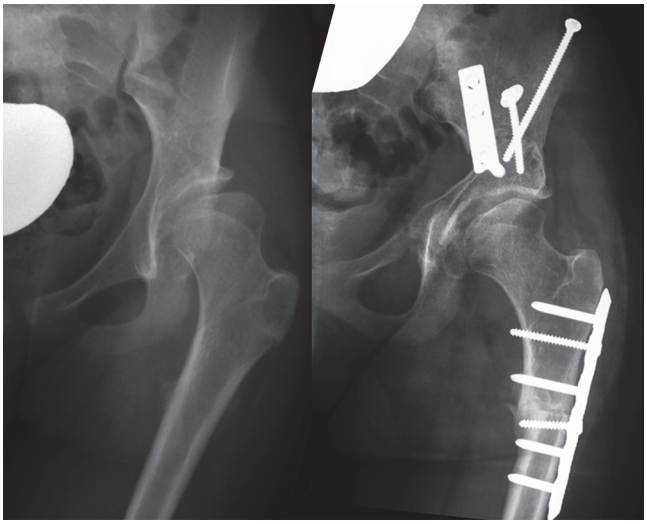

Fig. 3

Pre-operative and four month post-operative radiographs of a 21-year-old patient with severe dysplasia treated with Birmingham Interlocking Pelvic Osteotomy (with a degree of deliberate over-correction) and femoral shortening osteotomy.

osteotomies are made forming two equal interstitial angles that will determine the extent of lateral coverage to be gained, in accordance with pre-operative planning (Fig. 1). All bony cuts are carried out under direct vision, with important neurovascular structures safely retracted. Two external fixator pins are applied to the central acetabular fragment (CAF), offset in the transverse axial and mid-coronal planes by the degree of desired axial and coronal correction, respectively. When the CAF is subsequently rotated to the desired position, the external fixator pins become aligned with the axial and coronal planes, providing visual confirmation of successful positioning, thereby increasing the accuracy and predictability of realignment (Fig. 2). Once realigned, the three interconnected iliac osteotomies create an interlocking construct with good bony apposition and improved fragment stability, increasing the patient's and therapist's confidence with immediate unrestricted weight-bearing.

The goals of surgery in this cohort were a slight over-correction of the LCE angle to reduce the load on the damaged anterolateral segment of the acetabulum and the labro-osseous junction and to place better-preserved cartilage in the new weight-bearing segment, to correct apical acetabular version to anatomical and to achieve a sourcil angle[25] of 0° (Figs 3 and 4). Patients were immediately allowed to fully weight-bear as tolerated on the operative leg, unless restricted by prior microfracture or femoral osteotomy.

A total of nine (seven retroverting and two anteverting) concomitant femoral osteotomies were performed (using Arbeitsgemeinschaft für Osteosynthesefragen Dynamic Compression Plates, Synthes, Oberdorf, Switzerland), to adjust torsion to the presumed ideal of 20° anteversion.

Patients were followed up using the Oxford Hip Score (OHS)[26] and the University of California Los Angeles Score (UCLA)[27,28] while the first 15 hips in 15 patients also had pre- and post-operative Harris Hip Scores.[29] These scores were obtained in our clinic at routine time-points during the patient's follow-up (six weeks, three months, six months, one year, then yearly thereafter). Radiological evaluation was performed by a single observer (DJ) on the pre-operative anteroposterior radiograph of the pelvis. The LCE and the

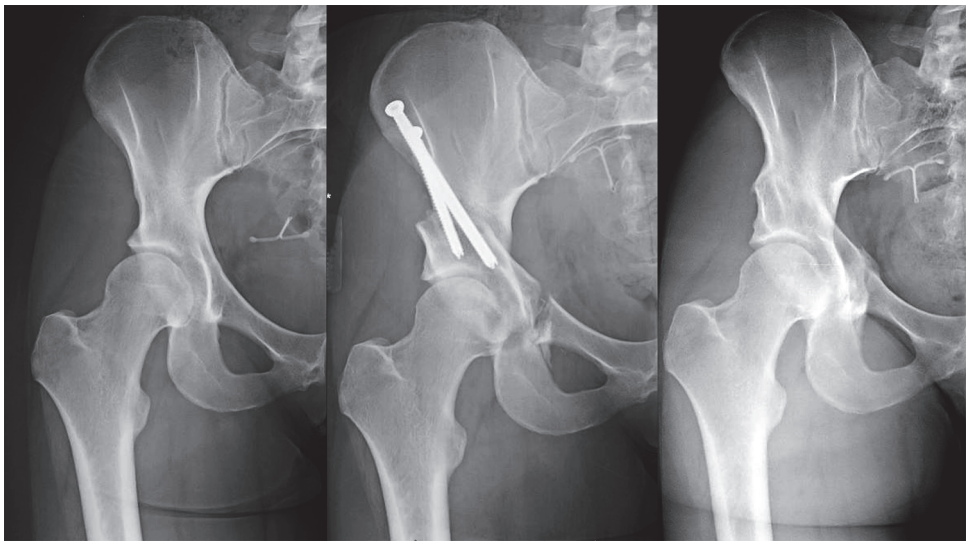

Fig. 4

Pre-operative and post-operative radiographs of a 31-year-old patient with borderline dysplasia of the right hip, treated with Birmingham Interlocking Pelvic Osteotomy (BIPO). Implants were removed after radiographic evidence of complete bony healing at six months post-operatively.

Table I. Characterisation of arthritis according to pre-operative Tönnis grade (only 66 original radiographs available for analysis)

Pre-operative Tönnis grade	Hips, n (%)
0	44 *(67)*
I	21 *(32)*
II	1 *(2)*

Table II. Mean difference between pre-operative and post-operative sourcil and lateral centre-edge (LCE) angles for 66 hips with pre-operative radiographs

	Pre-operative median (interquartile range, SD)	Post-operative (median (interquartile range, SD)	Mean difference (95% CI)
Sourcil angle (°)	21 (17 to 28, 7.1)	0 (-4 to 8, 8.2)	20.6 (18.1 to 23.0)
LCE angle (°)	15 (11 to 20, 8.4)	45 (38 to 54, 9.5)	30.7 (28.4 to 33.0)

SD, standard deviation; CI, confidence interval

sourcil angles were measured and the degree of osteoarthritis was evaluated using the Tönnis classification.[22] Routine follow-up was stopped at our institution after ten years, however all patients had radiographs within 12 to 18 months of completing the data collection for this study.

Statistical analysis. Along with survival calculations and Cox-proportional hazard modelling, analysis was performed using the R program, version 18 (R Foundation, Vienna, Austria). The primary outcome measure for this retrospective cohort study was conversion to hip arthroplasty. Secondary outcome measures were peri-operative complications, the OHS and the UCLA. The Cox-proportional hazards model was used to examine the relationship of the different survival distributions of each covariate entered into the model.[30] The baseline hazard for the group was extracted along with the relative proportional hazards for each of the covariates. The level of significance used for all comparisons was set to 95% (alpha < 0.05).

Results

The mean follow-up was 17.5 years (13.8 to 21.5). Three hips in three patients were lost to follow-up (2.5%). For the 66 hips (58 patients) with surviving radiographs, pre-operative arthritis grade is shown in Table I. The high mean post-operative LCE angle reflects the intended slight over-coverage in this original cohort (Table II). One hip (one of 116, 0.9%) was over-corrected into pathological retroversion, with subsequent iatrogenic anterior impingement requiring rim trimming. There was no significant difference between the post-operative LCE angle in surviving and failed BIPOs (49.8° *versus* 51.3°; p = 0.72, *t*-test).

At latest clinical follow-up, 38 hips (33%) had undergone hip arthroplasty (34 resurfacing type; four total hip arthroplasty). Hips that had not undergone hip arthroplasty exhibited a median OHS of 41 (interquartile range (IQR) 23.5 to 46.0) and a median UCLA of 5 (IQR 3 to 6.5). In all, 15 of these hips had pre- and post-operative

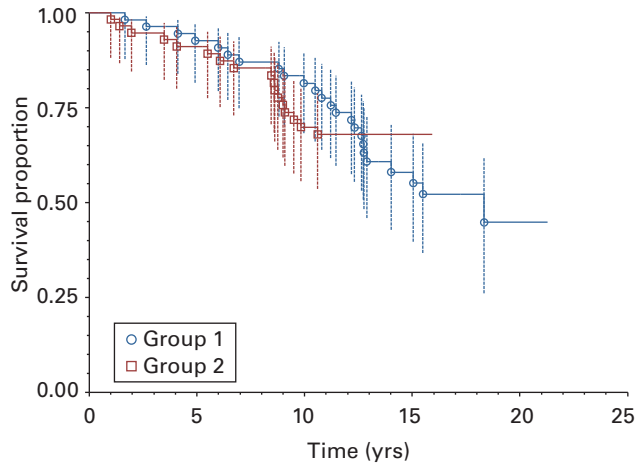

Fig. 5

Kaplan-Meier survival plot (PL estimates), including 95% confidence intervals, for group 1 (first 50 consecutive patients undergoing the Birmingham Interlocking Pelvic Osteotomy (BIPO)) showing 16 year survival of 52% and for group 2 (second 50 consecutive patients undergoing the BIPO) showing 16 year survival of 68%. Failure was defined as conversion to hip arthroplasty.

HHSs, with the median pre-operative score being 52 (IQR 48 to 54) and median post-operative score being 90.5 (IQR 90 to 100).

The mean survival at ten years and 17 years following treatment by BIPO was 76% (95% confidence intervals (CI) 66 to 83) and 57% (95% CI 46to 67%), respectively. When sub-stratifying this cohort into two groups, group 1 (the first 50 operated patients) and group 2 (second 50), a Kaplan-Meier survival plot indicated 52% (95% CI 37 to 66) survival for group 1 (Fig. 5) and 68% (95% CI, 54 to 79%) survival for group 2 (Kaplan-Meier survival plot, Fig. 5), suggesting improved outcome with the experience gained.

Increasing age at time of operation was a significant predictor of treatment failure: a hazard ratio (HR) of 1.03 for each yearly increase (95% CI 1.00 to 1.06, p = 0.024). The 35 to 40-year-old group had a HR of 1.85 increase in relative risk per year (95% CI 1.28 to 31.7, p = 0.024), and the > 40-year-old group had a HR of 1.55 (95% CI 1.05 to 21.0, p = 0.043) above the baseline hazard rate. The 20 hips in the < 20-year-old group had a Kaplan-Meier survival of 90% (95% CI 65 to 97) at 17 years.

The following were not found to be associated with surgery failure: pre-operative Tönnis osteoarthritis grade (0 nd I only) (p = 0.78), pre-operative sourcil angle (p = 0.23), pre-operative LCE angle (p = 0.54), post-operative sourcil angle (p = 0.93) and post-operative LCE angle (p = 0.54).

There were significant comorbidities that impaired functional scores, including one patient who has previously undergone below knee amputation; one Down syndrome; one post-polio syndrome; two patients with cerebral palsy; one patient with bilateral BIPOs had bilateral knee arthritis; and one patient with bilateral BIPOs had spinal stenosis.

Complications. There was one pulmonary embolism at 36 hours post-operatively from a contralateral 12-day old deep venous thrombosis; two deep venous thromboses in the opposite limb; three nonunions (two of the pubis and one of the ischium); one transient sciatic nerve palsy; two permanent lateral femoral cutaneous nerve injuries (almost all had sensory disturbance here for two to three months post-operatively); one case of iatrogenic pincer-type femoroacetabular impingement; and one infection. One patient from 1993, presented 14 years later with recurrent pain; the acetabulum was 15° excessively anteverted. This was corrected by a revision osteotomy and external rotation of the acetabular fragment. This patient is currently asymptomatic with an UCLA of 8 at ten years after the revision operation. There were a total of 12 complications (major; venous thromboembolism, nonunion, sciatic nerve palsy; and minor, 10.4%) of which five (4.3%) required additional surgery: the anterior impingement required rim resection; the three nonunions were bone grafted and united; and one hip required arthroscopic repair of a residual symptomatic labral tear from 11 o'clock to 2 o'clock. Overall rates of complication have decreased with growing surgical experience and decreasing operative time.

Discussion

The results of our study demonstrate that the BIPO is a viable option for treatment of acetabular dysplasia, with results during the early learning curve comparable with more established techniques. A total of 76% of the hips treated with BIPO have been preserved at ten years and 57% at 17 years, post-operatively. Of note, the study period was prior to the introduction and popularisation of the femoroacetabular impingement (FAI) concept.

The Tönnis and Bernese pelvic osteotomies allowed surgeons to correct acetabular dysplasia more accurately than with previous techniques.[15,17] However, these are known to have a steep learning curve with an associated high rate of complication.[18,31-33] The BIPO was developed to address the shortcomings of these two popular pelvic osteotomies. The use of a posterior mini-incision enables the surgeon to make the ischial cut under direct vision with the sciatic nerve retracted backwards away from the field. Our first patient had a transient sciatic nerve palsy and we mobilised the sciatic nerve more broadly in all later cases. This is in contrast to the Bernese osteotomy, as previously described. The BIPO does not seem to risk intra-articular osteotomy or unintentional propagation or fracture into the acetabulum, even when compared with rates reported in Ganz's own series.[34] These features make the BIPO less technically demanding than the Bernese osteotomy, with a shorter and less stressful learning period for the surgeon. The BIPO also eliminates the need for fluoroscopy during the majority of the procedure, until final realignment is to be verified and the fragment secured. The correction with the BIPO is reproducible and predictable, producing a stable

construct that enables immediate weight-bearing and rapid rehabilitation.

The overall rate of complication associated with the BIPO technique in our study was 10.4%, significantly lower than that described by Biedermann et al[35] for the Bernese PAO (minor complications of 41% and major complications of 37%). In a ten-year review of Ganz's first 75 PAOs, eight of the first 18 hips (44%) had a major complication.[36] In a further analysis of Ganz's first 508 PAOs published in 1999, it was noted that 85% of technical complications occurred during the first 50 procedures.[34] Our results, and those of others,[33,37] establish the BIPO to be less technically demanding than the Ganz technique, with a much lower rate of complication during the learning period. Other reports from different centres using various realignment techniques[8,35,36,38,39] have all reported much higher rates than the BIPO.

The venous thromboembolic events described in our series occurred long before the widespread use of post-operative anticoagulation for PAOs.[40] We have since been using aspirin 75 mg orally daily for three weeks for patients without a personal or family history of venous thromboembolism, and low molecular weight heparin for those with additional risk factors.

Only one of the hips in our series (one of 116, 0.9%) required anterior acetabular trimming for post-operative iatrogenic impingement, while another hip required revision BIPO 14 years after the index operation due to excessive anteversion. In contrast, other authors[38,41] have reported significantly higher rates of over-correction anteriorly, giving rise to iatrogenic impingement. This would suggest that accurate measurement of acetabular anteversion pre-operatively using CT scans is worthwhile, and that the distribution of the available acetabular coverage both anteriorly and posteriorly needs to be well balanced during the realignment procedure. In dysplasia, a pre-operative cross-over sign often occurs due to a hypovolemic acetabulum where the deficiency is predominantly posterior and lateral with normal anterior coverage. In these cases, it may be necessary to preserve some degree of crossover during the PAO deliberately, in order to avoid generating anterior instability. The BIPO technique aims to improve the accuracy and reproducibility of achieving optimal and balanced lateral and anterior coverage by using strategically placed external fixator pins as intra-operative guides and incorporating pre-operative CT findings in the planned correction.

Our results show that a slight over-correction in the lateral plane does not appear to contribute to FAI as much as over-correction anteriorly. There was a statistically insignificant difference in the LCE angle between our surviving and failed osteotomies. It is worth noting that the dysplastic acetabulum typically has a short up-sloping sourcil that, when realigned to a horizontal plane, gives rise to an enlarged LCE angle. Our data suggest that a large LCE angle may be accepted without consequence, as long as the version has been well balanced and post-fixation range of movement (30° of internal rotation at 90° of flexion intra-operatively) is adequate to rule out iatrogenic impingement.

Another important advantage of the BIPO over other pelvic realignment procedures is its inherent stability. Patients in our cohort were allowed to bear weight immediately post-operatively, and no loss of correction or other potential complications were seen with this accelerated rehabilitation regimen. Due to soft-tissue associated pain and weakness patients would still use assisting devices, such as crutches, to walk, but could bear weight as tolerated and was adopted by most, resulting in an overall faster resumption of independent walking and sports activities. Other PAO techniques typically require up to 12 weeks of non-weight-bearing until initial bony stability is achieved via strong callus formation.[9,15,42,43]

Our cohort predated the introduction and popularisation of the FAI concept. Nevertheless, patients with eccentricity of the femoral head, now known as cam type deformity, were identified on the CT scans and excluded from the current cohort. This decision, by the senior author (JNO-H), was due to his appreciation that incongruity would result in post-operative incongruity and jamming. Our cohort did include "mildly elliptical" heads if the main articulating surfaces were endospherical (i.e. the main articulating surface would conform to a sphere) with a flat sector laterally or medially, and where the surfaces were congruous in the intended position of correction on an image intensifier during examination under anaesthesia. Our results showed that a change in the relationship between the acetabulum and femoral head can be performed safely in these cases. Finally, while in the early 1990s cam impingement was not fully understood, the authors are now performing femoral osteoplasty, either prior to or during BIPO, to correct this conflict.

Our survivorship of 76% at ten years and 57% at 17 years compares well with survivorship reports of the Bernese osteotomy of 81% at 9.2 years[11] and 84% at ten years,[9] all sharing similar patient demographics. However, we should bear in mind that varying thresholds for conversion to arthroplasty can confound these comparisons. Patients undergoing BIPO had become used to greatly improved function and as a result we had a low threshold for conversion to arthroplasty when results started to deteriorate, perhaps sooner than would other surgeons. Most of our patients with failed BIPO underwent either a Birmingham (Midlands Medical Technology/Smith & Nephew, London, United Kingdom) or ADEPT (Finsbury Orthopaedics or MatOrtho, both Leatherhead, United Kingdom) hip resurfacing. Given that the bony acetabulum was well oriented from the BIPO, orientation and fixation of the acetabular component during conversion arthroplasty was unimpaired and less challenging than in patients with untreated dysplastic subjects. The reoriented acetabulum proved straightforward to address during the resurfacing for all patients. One patient was discovered to have a slightly mobile ischial osteotomy, which was addressed

with bone grafting at the same time. One acetabular resurfacing component fractured through the quadrilateral plate due to post-operative trauma in a motorcycle collision. The remaining acetabular components remained secure without need for revision at final follow-up.

Our results are in keeping with other reports[9,39] showing increasing failure rates in patients > 35 years of age and/or with advanced degenerative changes,[36,39,44,45] having improved functional scores in the lower grades of arthritis.[46] The arthritis grade, or the biological age of the joint, was found to be more important than the chronological age, with improvement in functional scores even above the age of 50 years, in Tönnis grade I and II.[47] As functional improvement in the presence of Tönnis grade I and II arthritis has been well established,[45,46,48] an age limit must be thoroughly considered, specifically with these highly active subjects. However, with the above in mind, the authors are now more cautious in recommending BIPO to patients older than 40 years of age, unless the joint is biologically young. We look for good cartilage status on MRI, an endospherical head, a good head-neck ratio or a correctible cam deformity, and a Tönnis arthritis grade of 0 to I.

Although acute symptoms of a torn labrum in hip dysplasia are common,[2,3,47] isolated labral surgery, without addressing the inadequate bony coverage, is ineffective in such circumstances and often harmful.[49,50] At the beginning of our series, the radiographic appearance of a labral tear on MRI was ignored, as the senior author (JNO-H) believed that the labral tear would become asymptomatic once the acetabular orientation was corrected. Indeed, only one patient from this cohort required arthroscopic labral surgery at follow-up. Apart from its use to assess cartilage status and to address intra-articular pathology prior to pelvic osteotomy, we remain sceptical of the therapeutic value of arthroscopy as a stand-alone procedure in dysplastic patients.

Limitations of this study include inconsistency in collection of pre- and post-operative pain assessment records and hip function scores in many patients. However, conversion to hip arthroplasty as the primary outcome measure served as a valid endpoint to the BIPO technique, with only 2.5% loss to follow-up. Additionally, many of our post-operative CT scans, now 16 to 22 years old, were lost during the hospital's archive relocation, which prevented us from including formal CT analysis. This analysis was further limited when we stopped obtaining routine post-operative CT scans after the initial cohort of 25 patients. This decision was made, however, in the interest of patient safety and radiation reduction, given that abnormalities in version (+/- 5°) were not detected. In common with many retrospective studies, our inability to review all the radiographs may have confounded details, but not the overall conclusions. Our study also had a significant loss to radiographic follow-up, making it difficult to correlate outcomes with pre-operative LCE, Tönnis angle, and Tönnis grade of arthritis.

In conclusion, hips treated with the BIPO for acetabular dysplasia demonstrated survivorship of 76% (95% CI 66 to 83) at ten years and 57% (95% CI 46 to 67) at 17 years, with good function and little or no pain. BIPO allows accurate, reproducible and stable positioning and fixation of the central acetabular fragment, permitting immediate post-operative weight-bearing and rapid rehabilitation. As with other operations, there was an increasing rate of failure with increasing patient age and hip arthritis grade. The operation is safe and reliable, with a low overall rate of complication, and its rates of survival are comparable with the Bernese PAO, even while the surgeon is acquiring technical experience.

Take home message:

- BIPO is a less well-known technique for osteotomy of the acetabulum; it incorporates pre-operative planning of the interlocking iliac osteotomy cuts to facilitate reliable execution of the intended bony correction and much faster weight-bearing and rehabilitation.
- It has comparable long-term clinical and radiographic outcomes with more established techniques, but with a much lower rate of complication even during the learning curve.
- Given the shortage of pelvic osteotomy surgeons worldwide, and perceived risks of Bernese PAO, perhaps the less complicated and more reproducible BIPO may prove more appealling.

Author contributions:

O. Mei-Dan: Analysis and interpretation of data, Drafting manuscript, Review and editing of manuscript.
D. Jewell: Analysis and interpretation of data, Drafting manuscript, Review and editing of manuscript.
T. Garabekyan: Analysis and interpretation of data, Drafting manuscript, Review and editing of manuscript.
J. Brockwell: Analysis and interpretation of data, Review and editing of manuscript.
D. A. Young: Analysis and interpretation of data, Review and editing of manuscript.
C. W. McBryde: Analysis and interpretation of data, Review and editing of manuscript.
J. N. O'Hara: Performed the operations; Analysis and interpretation of data, Drafting manuscript, Review and editing of manuscript.

The operation should not be attempted without reading this material carefully, contacting one of the authors if required and obtaining the correct instruments.

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No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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