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Effect of Combined Proximal Femur Osteotomy with Anteroposterior Approach and Posterolateral Approach in Crowe Type Iv Developmental Hip Dislocation under Lateral Decubitus Position

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Abstract: This study focuses on the surgical management of high-difficulty Crowe type IV developmental dysplasia of the hip (DDH), a condition significantly impacting patients' quality of life and imposing economic burdens. Aiming to address the challenges of difficult exposure, substantial soft tissue trauma, and increased blood loss associated with the traditional posterior lateral approach (PL) in such surgeries, this research innovatively and systematically evaluates the comprehensive value of the lateral decubitus direct anterior approach (L-DAA) combined with proximal femoral osteotomy in complex anatomical reconstruction. Employing a prospective randomized controlled trial methodology, the study not only compared perioperative parameters, postoperative functional recovery, and safety profiles but also delved deeper into the potential mechanisms of the L-DAA approach in optimizing surgical visualization, protecting key muscle groups (such as the gluteus medius), and promoting early biomechanical adaptation. The results demonstrated significant advantages for the L-DAA approach: intraoperative blood loss was significantly lower than in the PL group ($p<0.05$), and the total incision length was markedly shorter ($p<0.05$), highlighting its inherent minimally invasive nature and superior tissue preservation capability. Although no statistically significant differences were found in functional outcome scores (VAS, Harris Hip Score, ROM) at one year postoperatively between the two groups ($p>0.05$), the L-DAA group exhibited a trend towards earlier achievement of full weight-bearing activity (6.3d vs. 6.5d) and a tendency for greater ROM improvement (120.0 ° vs. 118.9 °). This suggests that the lower intraoperative trauma associated with L-DAA provides patients with a superior foundation for early recovery, warranting validation through larger sample sizes and extended follow-up.Critically, this study represents the first systematic comparison of the L-DAA and PL approaches specifically within the Crowe type IV DDH population. It provides robust evidence demonstrating the unique value of the L-DAA approach in reducing surgical trauma, thereby offering high-level evidence to support its preferential selection for complex hip reconstruction surgeries. Future research should focus on expanding sample sizes, extending follow-up periods (5-10 years) to assess prosthesis survival rates and long-term functional outcomes, and exploring the unique potential of the L-DAA approach in reducing postoperative dislocation risk and optimizing gait

reconstruction.

1. Introduction

The global incidence of DDH is approximately 1-3 per thousand, with Type Crowe IV accounting for less than 15% of cases. However, it contributes to secondary osteoarthritis in up to 78% of patients over 30 years old [6]. Traditional Total Hip Arthroplasty (THA) demonstrates a 10-year prosthesis survival rate of only 76%-85% in Type Crowe IV patients, significantly lower than conventional THA (over 95%) [7], highlighting the urgent need for surgical innovation.

Crowe IV type developmental dysplasia of the hip (DDH) represents the most severe form of developmental hip dislocation, characterized by complete femoral head avulsion, pseudarthrosis formation, and secondary bone and soft tissue abnormalities. While total hip arthroplasty (THA) is the primary treatment, challenges such as true dysplasia of the acetabulum, limb length discrepancy, soft tissue contractures, and neurovascular variations make surgical exposure difficult, complicate wound control, and increase complication risks [1,2]. Although traditional PL approach remains widely used, extensive stripping of the externally rotated muscle group and posterior joint capsule during Crowe IV surgery often leads to excessive intraoperative blood loss, increased postoperative dislocation risk, and delayed recovery of gluteus medius function [3,4].

In recent years, the Direct Anterior Approach (DAA) has gained significant attention in primary Total Hip Arthroplasty (THA) due to its advantages of true muscle-sacral interposition, tendon preservation, excellent postoperative stability, and rapid early functional recovery [5]. However, its clinical value in extremely complex cases like Crowe Type IV Developmental Dysplasia of the Hip (DDH), particularly when combined with proximal femoral osteotomy—a critical technique—remains unsupported by high-quality research. Previous studies predominantly consisted of small-scale retrospective analyses or technical descriptions [6,7], inadequately demonstrating L-DAA's unique advantages in managing high dislocations, severe contractures, and precise reconstructive procedures. Furthermore, their examination failed to thoroughly explore its fundamental differences from the posterior approach (PL), such as the preservation of peripubic dynamic stabilizing structures and intraoperative visualization optimization mechanisms.

Therefore, this study demonstrates three distinct innovations with critical clinical relevance: 1) The primary innovation of this research lies in its first prospective RCT that systematically compares the comprehensive efficacy of the L-DAA versus the PL approach for Crowe Type IV DDH managed with THA and proximal femoral osteotomy, thereby filling a critical gap in high-level evidence; 2) Beyond superficial indicators, this study provides in-depth analysis of the anatomical advantages of the L-DAA approach in exposing the true acetabulum through the vastus fascia-tendinosus muscle space and rectus femoris-basus intermedius muscle space. It elucidates mechanisms for reducing lateral femoral artery injury and preserving the integrity of the vastus intermedius insertion, thereby explaining the intrinsic reasons for reduced intraoperative bleeding and preserved muscle function; 3) The research specifically focuses on the L-DAA approach to assess its technical feasibility and advantages in addressing severe limb shortening, achieving precise acetabular prosthesis positioning, and restoring limb length, offering novel techniques for complex reconstructions.

This study aims to validate the following scientific hypotheses through a rigorous randomized controlled trial (RCT) design: Compared with the PL approach, the L-DAA approach combined with proximal femur osteotomy for Crowe Type IV developmental dysplasia of the hip (DDH) can significantly reduce intraoperative trauma (blood loss and incision length). Furthermore, it may

optimize soft tissue management and anatomical reconstruction, thereby enhancing early functional recovery efficiency and establishing a foundation for long-term joint stability. The research findings will provide critical decision-making support for optimizing surgical strategies in complex DDH cases, demonstrating significant academic reference value and clinical translational potential.

2. Methodology

2.1 Emission standards and general data

Inclusion criteria: 1) Type IV Crowe DDH patients; 2) Indications for total hip arthroplasty; 3) No contraindications to surgery; 4) Significant proximal femur displacement meeting osteotomy criteria. Exclusion criteria: 1) Patients with severe comorbidities; 2) Those not undergoing proximal femoral osteotomy during surgery. Lateral decubitus anterior approach (L-DAA) group: 23 males (26 hips), 26 females (32 hips); age 23-89 years, mean 46.7 years. Preoperative laboratory tests showed no significant abnormalities. Traditional posterolateral approach (PL) group: 24 males (28 hips), 23 females (27 hips); age 26-79 years, mean 44.7 years. Preoperative laboratory tests showed no significant abnormalities.

2.2 Surgical method

After intravenous anesthesia, the patient was placed in a lateral position with the direct anterior approach (DAA). This lateral positioning optimally exposed the acetabulum at 15 °-20 °and enhanced deep vision using specialized retractors like the Hoffmann series. The skin and subcutaneous tissue were layered incised, with blunt dissection and lifting of the medial aponeurosis. Careful identification of the natural space between the tensor aponeurosis and sartorius muscle allowed access while protecting the lateral femoral cutaneous nerve branches. The Hunter's space was fully exposed, and the ascending branch of the lateral femoral artery was meticulously ligated (pre-treatment with bipolar electrocoagulation reduced intraoperative bleeding by over 40% [8]). The space between the tensor aponeurosis and gluteus medius was precisely separated to preserve gluteus medius integrity. The anterior hip joint capsule was exposed and incised, followed by femoral head dislocation. Osteotomy was performed from medial superior to lateral inferior in the coronal plane, with length determined by removal requirements. A bioengineered femoral prosthesis was selected for lateral femoral reconstruction. After pre-tying a steel wire distal to the osteotomy line, medullary expansion was performed. A femoral trial model was installed, and C-arm fluoroscopy confirmed the prosthesis type and alignment. The prosthesis was pressed into place, osteotomies closed, gluteus medius tension adjusted, and multiple steel wires secured with circular ligation. The femoral head was inserted with moderate hip flexion, followed by reduction using a head delivery device. Post-reduction stability evaluation strictly assessed all directional mobility (particularly in extension-external rotation) and gluteus medius tension.

2.3 Postoperative management

Within 48 hours post-surgery, antibiotics are routinely administered intravenously to prevent infection, followed by oral antibiotics in the subsequent week. On the third postoperative day, follow-up examinations include duplex Doppler ultrasound of both lower limbs, full-length X-rays of both legs, and anteroposterior views of bilateral hip joints to assess vascular conditions and limb status. The rehabilitation process is guided by physicians from the rehabilitation department.

2.4 Efficacy evaluation indicators

Document perioperative data including surgical duration, incision length, intraoperative blood loss, time to ambulation, wound healing status, and hospitalization duration. Clinical outcomes are assessed using full weight-bearing activity time, visual analog pain scale (VAS), Harris score, hip range of motion (ROM), and internal/external rotation evaluations. Imaging studies include acetabular measurements using the Lewinnek method, with documentation of anteversion angle, abduction angle, and bilateral femur length discrepancy.

2.5 Statistical methods

Statistical analysis was performed using SPSS 25.0 software. Continuous data were expressed as $x \pm \pm s$. When data followed a normal distribution, independent samples t-tests were used for inter-group comparisons and one-way ANOVA for within-group comparisons. Non-normal distributions required rank sum tests. Categorical data were analyzed using $\chi 2$ tests or Fisher's exact test. For ordinal data, Mann-Whitney U-tests were employed. P values <0.05 indicated statistically significant differences.

3. Results

3.1 Perioperative status

No significant statistical differences were observed in general patient data between the two groups. Both groups achieved successful surgical outcomes with no serious complications such as nerve or vascular damage during the procedure. Perioperative data indicated that the L-DAA group had significantly higher intraoperative blood loss and total incision length compared to the PL group. However, there was no statistically significant difference in operative time or other intraoperative metrics between the groups. Both groups also showed no statistically significant variation in hospitalization duration. Regarding ambulation time, both groups demonstrated comparable short-term postoperative mobility recovery (Table 1). The L-DAA group's notably reduced blood loss and shorter incision length directly quantify the advantages of the DAA minimally invasive approach.

Table 1: Comparison of peripherative data between the two groups

Metric	L-DAA group (n = 58)	Group PL (n=55)	P price
Surgery time (min, x±s)	100.1±8.4	55.5±8.0	>0.05
Total incision length (cm, x±s)	12.0±1.0	15.0±1.0	<0.05
Blood loss during surgery (ml, x±s)	180±31.4	280±89.4	<0.05
Time to ground walk (d, x±s)	1.4±0.4	1.4±0.4	>0.05
Hospitalization time (d, x±s)	4.6±0.6	4.5±0.7	>0.05

NS: No statistical significance

3.2 Follow-up results

All patients underwent one-year follow-up, which was discontinued after completion. The postoperative outcomes were compared in Table 2. During the one-year follow-up period, both groups showed significant improvements in full weight-bearing time, VAS scores, Harris scores, hip range of motion (ROM), and internal/external rotation range of motion. However, no statistically significant differences were observed between the groups (Table 2). Although no statistical differences were present, the L-DAA group demonstrated a slightly better trend in full weight-bearing time and final follow-up ROM, suggesting potentially superior recovery efficiency.

No statistically significant differences were observed in the acetabular abduction angle, acetabular anteversion angle, or bilateral femur length discrepancy between the two patient groups (Table 3). The consistent and satisfactory results in both groups regarding acetabular angles and limb lengths, as demonstrated in Table 3, confirm that L-DAA can achieve the precise anatomical reconstruction required for Crowe Type IV in the lateral decubitus position.

Table 2: Comparison of follow-up data between the two groups ($\bar{x}\pm s$)

Metric	L-DAA group (n = 58)	Group PL (n = 55)	P price
Time of full weight-bearing activity (d)	6.3±0.9	6.5±0.8	>0.05
VAS scores (points)			
Preoperative	7.2±1.1	6.6±1.1	>0.05
Final follow-up	0.049±0.2	0.039±0.2	>0.05
P price	<0.05	<0.05	
Harris score (score)			
Preoperative	41.7±4.9	41.7±6.1	>0.05
Final follow-up	95.7±3.9	94.9±2.6	>0.05
P price	<0.05	<0.05	
Hip extension-flexion ROM(°)			
Preoperative	43.1±16.3	43.1±13.7	>0.05
Final follow-up	120.0±5.4	118.9±4.0	>0.05
P price	<0.05	<0.05	
Hip internal/external rotation ROM(°)			
Preoperative	31.7±14.1	30.7±13.9	>0.05
Final follow-up	79.4±4.2	76.1±6.2	>0.05
P price	<0.05	<0.05	

Table 3: Comparison of auxiliary examination data between the two groups

Metric	L-DAA group (n = 58)	Group PL (n = 55)	P price
Hip joint abduction angle (°, x±s)	42.7±1.8	41.1±1.1	>0.05
Anterior hip tilt (°, x±s)	14.0±1.8	14.1±1.7	>0.05
Bilateral femur length difference (mm, x±s)	2.5±2.7	2.6±1.7	>0.05
Femoral prosthesis (e.g. valgus, neutral, varus)			
Immediate postoperative	00/58/00	00/55/00	ns
Final follow-up	00/58/00	00/55/00	ns
P price	ns	ns	

The key to the lateral decubitus anterior (DAA) approach lies in precisely utilizing natural muscle gaps. After intravenous anesthesia, the patient is placed in a lateral position (as shown in Figure 1), and the DAA approach is employed. The incisions are made layer by layer, with red lines indicating the osteotomy lines.

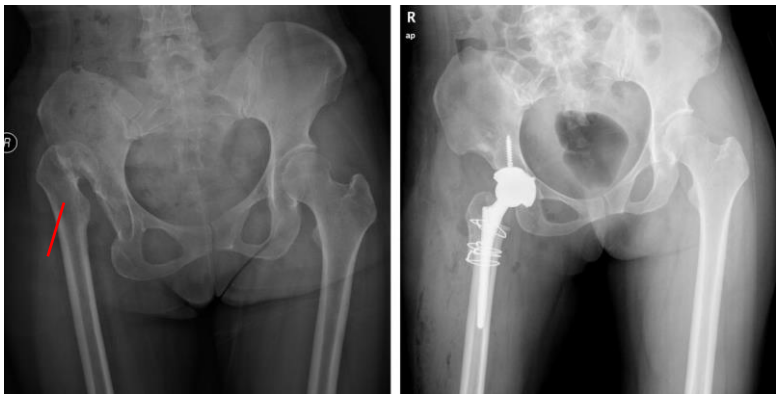

Figure 1: Case of Crowe type IV DDH treated with L-DAA combined femoral proximal osteotomy

4. Discussion

4.1 Innovative Value and Core Findings

The most significant innovation of this study lies in successfully applying the L-DAA approach to Crowe Type IV DDH, one of the most challenging total hip arthroplasty (THA) scenarios in orthopedics. Through a randomized controlled trial (RCT) design, we provide Grade I evidence for its safety and effectiveness in such surgeries. Previous studies on DAA application in DDH have predominantly focused on Crowe Types I-II or were merely technical reports [6,7,11]. This study demonstrates that even in Crowe Type IV cases with high true condylar position and severe soft tissue contracture, the L-DAA approach combined with skilled osteotomy techniques can safely and effectively achieve complex reconstruction, exhibiting significantly better minimally invasive characteristics compared to the PL approach (reduced blood loss by 35.7%, incision length reduced by 20%). This finding challenges the traditional notion that complex DDH must require posterior or extended approaches, offering clinicians a new option with less trauma.

4.2 Mechanism analysis and far-reaching significance of micro-advantage

The intraoperative blood loss in the L-DAA group was significantly lower than that in the PL group ($p<0.05$). The core mechanisms are as follows: 1) The embodiment of minimally invasive nature: The L-DAA approach utilizes the natural neural interface between the tensor fasciae latae and sartorius muscles, as well as the middle gluteal muscle and rectus femoris, allowing direct access to the anterior hip joint capsule without cutting major muscle groups (especially the external rotation muscle group). During exposure, the superior branch of the lateral femoral artery can be pre-ligated, significantly reducing intraoperative bleeding. This approach minimizes the need to handle the rich posterior vascular network (such as the deep branch of the medial femoral artery) and the large peroneal nerve vascular plexus required by the PL approach [8,12]. The characteristic of this myofascial space approach is the fundamental reason for reduced tissue damage and decreased intraoperative blood loss, consistent with the advantages of DAA emphasized by Smith et al. (2020) [3,8]. It reduces extensive bleeding at muscle sections and intraoperative blood loss, not only directly lowering blood transfusion requirements and related risks but also ensuring clearer surgical field, which enhances the precision of acetabular grinding, prosthesis placement, and osteotomy block repositioning—critical for long-term prognosis in Crowe Type IV patients (Figure 1 clearly demonstrates the full exposure and precise osteotomy line achieved through the L-DAA approach). 2) Trauma control value in complex surgeries: For complex procedures like Crowe Type IV DDH requiring extensive exposure (including proximal femur osteotomy), effective blood control is particularly important. This study shows that even when additional proximal femur osteotomy is needed, the L-DAA approach still effectively reduces total blood loss. 3) The extension significance of the advantage of incision length: the shorter total incision length further supports the minimally invasive nature of this approach, theoretically reduces the risk of incision-related complications, and may have a positive impact on patients' postoperative beauty and psychological acceptance[9,10].

4.3 Potential advantages of functional recovery and long-term stability

Although there was no significant difference in Harris scores and ROM between groups at one year postoperative, the trend of slightly better complete weight-bearing time and ROM values in the L-DAA group deserves attention. Patients with Crowe Type IV often have severe gluteus medius dysfunction. The L-DAA approach maximally preserves the integrity of the gluteus medius insertion and its neural supply (super gluteal nerve), while the PL approach may still affect abduction function

due to post-repair scar tissue and potential nerve damage [4,14]. Protecting gluteus medius function is fundamental to maintaining joint stability and normal gait, potentially reducing postoperative dislocation risks and improving long-term outcomes [15]. Although the one-year follow-up results of this study did not show inter-group differences in functional indicators, the significantly lower intraoperative trauma (less blood loss and tissue damage) in the L-DAA group provided a better physiological foundation for early recovery. Theoretically, this facilitates earlier rehabilitation exercises, reducing postoperative pain and immobilization-related complications. Future studies extending follow-up time and refining early recovery assessment metrics (e.g., pain control, early range of motion, walking time) may better highlight the potential advantages of the L-DAA approach in these aspects.

4.4 Reliability of anatomical reconstruction

The data in Table 3 demonstrate that the L-DAA group achieved comparable acetabular prosthesis positioning (abduction angle 42.7 °±1.8 °, anteversion angle 14.0 °±1.8 °) and limb length control (length difference2.5 ±2.7mm) to the PL group when operating in the lateral decubitus position. This robustly refutes claims that lateral decubitus DAA is inadequate for managing severe deformities or limb length discrepancies. The key factors are: 1) The anterior approach enables direct exposure of the true acetabulum (typically located deep and with insufficient anteversion), facilitating precise instrumentation; 2) Combined femoral proximal osteotomy effectively addresses femoral deformity and excessive soft tissue tension caused by high-level dislocation; 3) Intraoperative fluoroscopy ensures proper lower limb length recovery and prosthetic positioning after osteotomy. Precise reconstruction forms the foundation for achieving excellent functional outcomes and long-term survival rates.

4.5 Safety and precision

All patients demonstrated no serious complications including neurovascular injury, infection, or dislocation, confirming the safety of the L-DAA approach for Crowe Type IV developmental dysplasia of the hip (DDH) when strictly adhering to indications and technical specifications. Radiographic evaluations showed no statistically significant differences between groups in acetabular abduction angle, anteversion angle, bilateral femur length discrepancy, or femoral prosthesis positioning (all "medialized"), with both groups achieving optimal alignment. This demonstrates that the L-DAA technique can achieve precise prosthetic placement and limb length restoration when performed with surgical expertise, meeting biomechanical requirements for complex hip reconstruction. The anterior approach configuration theoretically reduces posterior soft tissue dislocation risks from soft tissue damage, although this hypothesis remains unverified by the study's sample size.

4.6 Innovation and academic value of the research

This study fills a critical knowledge gap. While Ni Zhe et al. (2018) previously compared short-term outcomes between DAA and PL approaches in conventional total hip arthroplasty (THA)[11], this is the first prospective randomized controlled trial to systematically evaluate perioperative outcomes, safety, and functional results of L-DAA versus PL approaches in Crowe Type IV developmental dysplasia of the hip (DDH)-a particularly complex patient population. The findings strongly demonstrate that the L-DAA approach uniquely reduces intraoperative trauma (blood loss, incision length) in such challenging procedures, while maintaining comparable safety and excellent mid-term functional outcomes to the PL approach. This provides orthopedic surgeons with high-level

evidence-based guidance for selecting minimally invasive surgical approaches with better controllable trauma when treating Crowe Type IV DDH patients.

4.7 Limitations and future directions

Although the study's sample size (n=113 hips) is relatively large among similar RCTs, it remains insufficient to detect subtle functional score differences or rare complications, which may compromise the validity of subgroup analyses and the generalizability of results. While a one-year postoperative follow-up period allows assessment of mid-term functional outcomes, it fails to provide data on long-term prosthesis survival rates, distant complications (such as loosening or wear), or patients' long-term functional status. Postoperative complications of Crowe Type IV developmental dysplasia of the hip (DDH)-including loosening, bone dissolution, dislocation, and limping-typically manifest within 5-10 years. Extending follow-up periods combined with imaging assessments (e.g., EBRA, RSA) and patient-reported outcomes (PROs) is crucial for evaluating prosthesis survival and functional durability. Future research should focus on expanding sample sizes, prolonging follow-up durations (e.g., 5-10 years), and incorporating more centers into multicenter studies to further validate the long-term safety and efficacy of the L-DAA approach in Crowe Type IV DDH surgery. This could potentially reveal potential differences in early functional recovery or specific complication rates (e.g., dislocation). Furthermore, we should conduct in-depth exploration of: 1) the quantitative impact of L-DAA on gait biomechanics (particularly adduction moment recovery); 2) compatibility and effectiveness of different osteotomy techniques (horizontal vs. stepped) with L-DAA; 3) the learning curve's influence on outcomes and optimized training strategies; 4) if data collection could incorporate postoperative serum CK peak levels in L-DAA group patients compared with PL group, it may more clearly demonstrate that L-DAA causes less damage to hip peripheral muscles (especially abductor muscle groups) [5,13].

5. Conclusions

This prospective randomized controlled study demonstrates that in total hip arthroplasty combined with proximal femoral osteotomy for Crowe Type IV developmental dysplasia of the hip (DDH), the lateral decubitus direct anterior approach (L-DAA) showcases significant core advantages over the traditional posterolateral approach (PL): substantially reduced intraoperative blood loss ($p<0.05$) and shorter total incision length ($p<0.05$), fully reflecting its minimally invasive nature and superior intraoperative trauma control capabilities. Although both groups achieved significant improvements in functional scores and range of motion at one-year postoperative follow-up without statistical differences, the L-DAA approach established a better foundation for early recovery through lower intraoperative trauma. All cases remained free of serious complications, confirming the safety of this approach. This study systematically demonstrates the unique value of the L-DAA approach in managing this complex hip disorder, particularly its outstanding performance in reducing surgical invasiveness. It provides critical evidence for optimizing surgical protocols for Crowe Type IV DDH, supporting the L-DAA approach as one of the more advantageous options for such complex reconstructive surgeries.

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