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Original Article

Clinical efficacy and prognostic analysis of autologous femoral head structural bone grafting combined with total hip arthroplasty for Crowe Type II/III developmental dysplasia of the hip in adults

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Abstract: Objective: To evaluate the clinical efficacy and mid-term outcomes of total hip arthroplasty (THA) assisted by acetabular reconstruction using autologous femoral head structural bone grafting in patients with Crowe type II/III developmental dysplasia of the hip (DDH). Methods: A retrospective analysis was conducted on 100 patients (100 hips) with Crowe type II/III DDH who underwent THA at the Affiliated Hospital of Xuzhou Medical University between January 2019 and December 2022. All patients received autologous femoral head structural bone grafting for acetabular reconstruction during the procedure. Perioperative parameters, visual analogue scale (VAS) scores, limb length discrepancy (LLD), range of motion (ROM), hip function [Harris hip score and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)], incidence of complications, quality of life [Generic Quality of Life Inventory-74 (GQOLI-74)], and radiographic outcomes were assessed. Results: The mean follow-up duration was 10.78 ± 1.65 months. Postoperatively, the VAS score significantly decreased from 6.52 ± 2.58 to 1.73 ± 0.72 (P < 0.001), and the LLD reduced from 2.88 ± 0.54 cm to 0.92 ± 0.39 cm (P < 0.001). The Harris hip score increased from 58.23 ± 6.14 to 92.45 ± 5.82 (P < 0.001), while the WOMAC score decreased from 72.54 ± 8.61 to 18.34 ± 5.09 (P < 0.001). All domains of the GQOLI-74 score showed significant improvements (P < 0.001). The overall complication rate was 1.0%, and radiographic assessments confirmed bone healing. Conclusion: THA assisted by autologous femoral head structural bone grafting is a safe and effective approach for treating Crowe type II/III DDH. It significantly enhances hip function, restores biomechanics, improves the quality of life, and is associated with a low complication rate and favorable mid-term outcomes.

Keywords: Autologous femoral head structural bone grafting, total hip arthroplasty, Crowe Type II/III, developmental dysplasia of the hip, prognostic analysis

Introduction

Developmental dysplasia of the hip (DDH) is a common orthopedic condition characterized by varying clinical manifestations depending on the patient's age, disease severity, and whether the involvement is unilateral or bilateral. Typical symptoms include hip pain, limited range of motion, and abnormal gait, all of which can substantially impair daily functioning and quality of life [1]. The Crowe classification remains the most widely used system for categorizing DDH, dividing cases into four types based on the extent of femoral head displacement. In Crowe Type II/III DDH, there is marked acetabular bone deficiency, particularly at the apex and posterior-superior aspect of the true acetabulum, which presents significant surgical challenges [2]. Total hip arthroplasty (THA) is currently the mainstay treatment for Crowe Type II/III DDH, as it can restore joint function, alleviate pain, and improve patients' quality of life [3, 4]. However, optimal acetabular cup placement in these cases remains controversial, especially regarding whether to medialize or superiorize the hip's center of rotation, or to perform anatomical acetabular reconstruction. Simply medializing the center of rotation may result in insufficient prosthetic coverage due to the extent of acetabular bone deficiency. While

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superiorizing the rotation center can effectively avoid the need for acetabular reconstruction and reduce surgical complexity, it may compromise the restoration of femoral offset and limb length, thereby impairing postoperative joint mobility. In contrast, anatomical reconstruction of the true acetabulum can better restore the native biomechanics of the hip and potentially reduce prosthesis wear. However, it requires careful management of acetabular bone defects and presents greater technical demands for the surgeon [5, 6].

To address the challenges mentioned above, several surgical techniques have been adopted in clinical practice, including high-level acetabular reconstruction, autologous bone structural bone grafting, and the use of smaller prosthetic components. Among these, high-level acetabular reconstruction remains the most commonly used approach [7]. Nevertheless, numerous reports have indicated that structural autografting using the femoral head or the implantation of tantalum metal blocks is also widely employed for acetabular reconstruction, each with distinct advantages and limitations. Specifically, structural grafting with the autologous femoral head has been shown to effectively restore lateral acetabular bone defects [8, 9]. However, improper handling of the graft intraoperatively may lead to postoperative resorption or collapse, thereby compromising prosthesis stability and adversely affecting long-term outcomes [10]. In this context, the present study retrospectively analyzed clinical data from 100 adult patients with Crowe Type II/III DDH who underwent THA, with a focus on evaluating the efficacy of autologous femoral head structural bone grafting in acetabulum reconstruction. The aim was to provide clinical insights and inform surgical decision-making for this specific patient population.

Material and methods

Clinical data

A retrospective analysis was conducted on 100 adult patients (100 hips) diagnosed with Crowe Type II/III DDH, who underwent THA at the Affiliated Hospital of Xuzhou Medical University between January 2019 and December 2022. The cohort consisted of 56 males and 44 females, with a mean age of 53.55 ± 4.19 years (range, 42-77 years). The affected side was the left hip in 52 cases and the right hip in 48 cases. According to the Crowe classification, 39 cases were Type II and 61 cases were Type III. The mean body mass index (BMI) was 22.89 ± 2.03 kg/m^2 (range, 17-29 kg/m^2). The leg length discrepancy ranged from 0.68 to 4.45 cm, with an average of 2.88 ± 0.54 cm. Ethical approval for this study was obtained from the Ethics Committee of the Affiliated Hospital of Xuzhou Medical University.

Inclusion and exclusion criteria

Inclusion criteria: (1) Diagnosis of DDH according to established clinical and radiographic criteria [11]; (2) Age ≥ 18 years; (3) Undergoing first-time THA with acetabular reconstruction using autologous femoral head structural bone grafting; (4) Complete clinical and follow-up data; (5) Crowe Type II or III classification; (6) Unilateral hip involvement with significant joint pain and restricted function.

Exclusion criteria: (1) Prior surgical intervention involving the affected hip; (2) History of hip trauma or infection; (3) Pregnancy or lactation; (4) Presence of malignant or severe systemic comorbidities; (5) Inability to tolerate anesthesia or surgery; (6) Marked symptom relief following conservative treatment.

Methods

Upon admission, all patients underwent comprehensive preoperative evaluations, including assessments of dislocation height, acetabular morphology, lower limb length discrepancies, and severity of bone defects. These evaluations were followed by individualized preoperative planning and the design of a patient-specific Inner Acetabular Plate (IAP) prosthesis. High-resolution computed tomography (CT) scans of the affected hip were obtained and imported into Mimics software for three-dimensional reconstruction, generating a complete pelvic model that clearly visualized acetabular structures and bone defects. Based on the patient's Crowe classification (Type II or III), an appropriately sized hemispherical acetabular component was selected, and virtual implantation simulations were performed to assess prosthetic coverage and stability. For defects located at the medial wall of the acetabulum, a computer-aided design (CAD) system was used to construct a personalized IAP prosthesis. The design process took into account the geometry of the defect and surrounding bone quality to optimize screw placement, including the number, length, and orientation of fixation screws, with the goal of maximizing initial stability. To ensure intraoperative precision, a patient-specific 3D-printed surgical guide was also designed to conform to the acetabular surface. The guide incorporated key alignment markers and predefined screw trajectories, effectively enhancing the accurate placement of the prosthesis and reducing surgical time. Subsequently, the IAP design underwent porous structure optimization using Magics (Materialise) software to enhance osseointegration while minimizing prosthesis weight. Pore diameter and distribution density were adjusted based on biomechanical requirements. The final porous IAP model was imported into a metal 3D printing device (BLT-300, Xi'an Bright Laser Technologies Co., Ltd., China) and fabricated using laser powder bed fusion (LPBF) technology, with high-purity spherical tantalum powder (15-53 um, Ningbo Luofei Nanotechnology Co., Ltd., China) as the material. After printing, the IAP prosthesis was trial-assembled and verified with a 3D-printed pelvic model to test prosthesis fit, surgical guide accuracy, and screw channel alignment, ensuring optimal intraoperative performance. The entire workflow - from data acquisition to prosthesis fabrication - was completed within approximately 8 to 10 days (**Figure 1**), ensuring thorough and precise preoperative planning and reliable execution of complex acetabular reconstructions.

All patients underwent general anesthesia with laryngeal mask airway (LMA) ventilation. Anesthesia was induced using intravenous sufentanil (0.1 μg/kg; Jiangsu Nhwa Pharmaceutical Co., Ltd., NSZ20K13), cisatracurium (0.15 mg/kg; Jiangsu Hengrui Pharmaceuticals Co., Ltd., 201108XA), and etomidate (0.3 mg/kg; Jiangsu Nhwa Pharmaceutical Co., Ltd., TYT19H36). Following induction, a multifunctional laryngeal mask was inserted approximately 15 minutes later to initiate mechanical ventilation. Ventilation parameters were adjusted intraoperatively according to each patient's respiratory status. To maintain intraoperative anesthesia and muscle relaxation, cisatracurium was administered intermittently, while continuous infusions of either propofol (Jiangsu Yingke Biopharmaceutical Co., Ltd., 11905091) or fentanyl (Yichang Humanwell Pharmaceutical Co., Ltd., AB40-903021) were used to ensure adequate anesthetic depth and hemodynamic stability.

All patients were placed in the lateral decubitus position. A posterior-lateral surgical approach was employed. The gluteus maximus was bluntly dissected, followed by a transection of the external rotator muscles. The thickened pseudocapsule was completely excised to expose the acetabular region fully. Adipose tissue within the acetabular fossa was removed, and the posterior acetabular ligament was visualized. The acetabulum was prepared at its anatomical location, and a trial prosthesis was inserted to confirm the area requiring bone grafting. Next, a small acetabular reamer was used to gradually remove the sclerotic bone within the pseudacetabular area at the acetabular dome until fresh bleeding from the bone surface was observed, confirming exposure of healthy cancellous bone. Subsequently, a small bone chisel was used to perform cortical stripping of the bone bed surface to increase its roughness and enhance biological fixation. The autologous femoral head was harvested, and its cartilage surface was completely removed. The cancellous bone was then carefully shaped to ensure an optimal fit with the acetabular bone bed. The cancellous bone chips created during reaming were evenly distributed over the acetabular surface to facilitate graft integration. The contoured autologous femoral head bone graft was then precisely positioned in the defect site. After verifying full contact between the bleeding bone surfaces of the graft and host bed, temporary fixation was achieved using a Kirschner wire (2.5×200 mm, Shandong Weigao Orthopaedic Device Co., Ltd.). Definitive fixation was secured using two cancellous bone screws (6.5 mm in diameter, 1.65 mm in thread depth; Suzhou Youbetter Medical Apparatus Co., Ltd., HAQ01), with screw tips penetrating the contralateral acetabular cortex to ensure robust initial mechanical stability and facilitate biological osseointegration. During the procedure, a reciprocating saw was used to excise the non-weight-bearing outer portion of the bone graft, which was then processed into backup bone particles for future use. The acetabular bed was subsequently re-reamed using an acetabu-

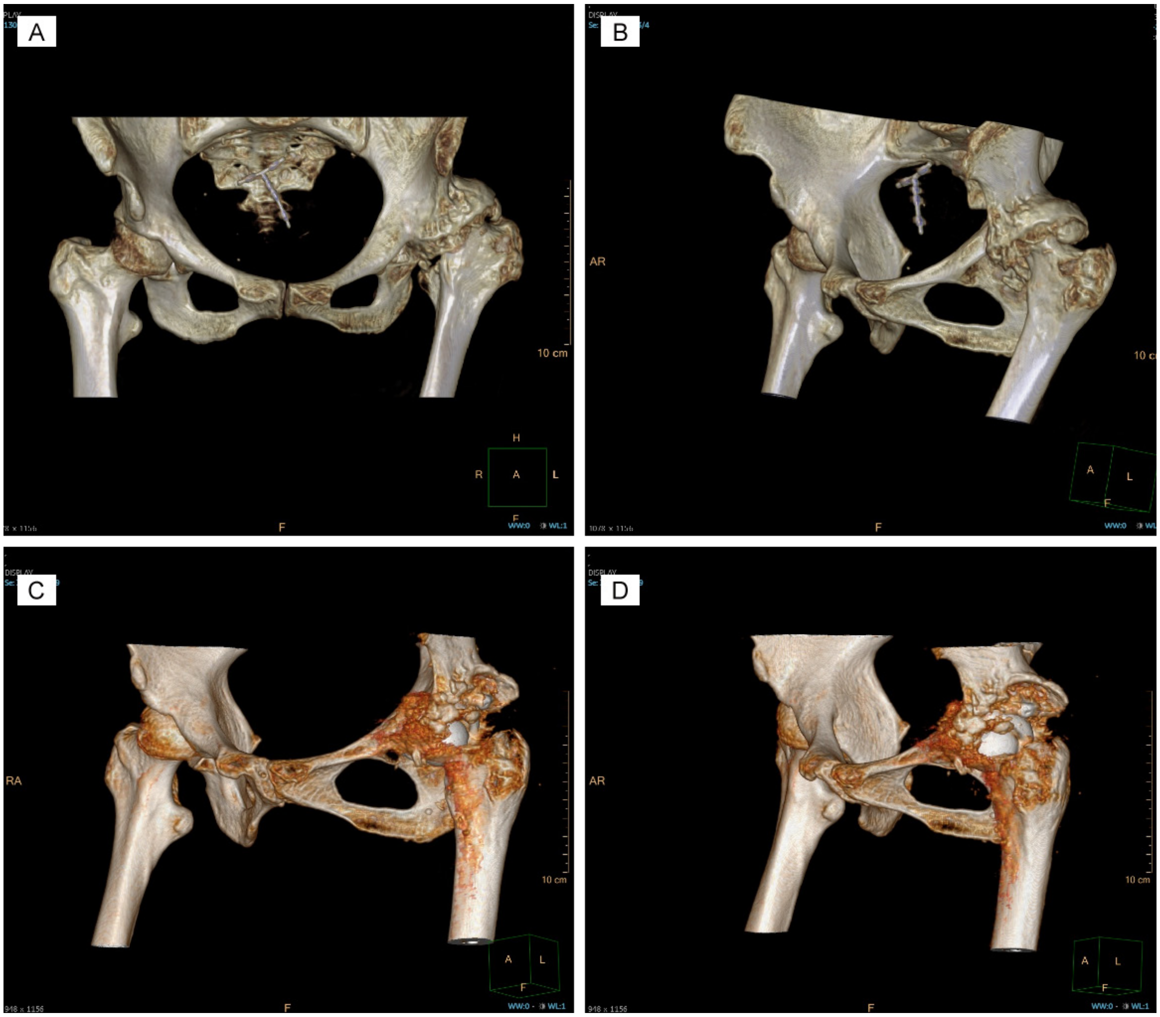

Figure 1. Three-dimensional reconstruction of the patient's pelvic model. A, B. Preoperative 3D CT images showed acetabular dysplasia characterized by relatively intact margins, a shallow acetabulum, and mild retroversion, consistent with the typical manifestations of Crowe type II/III DDH. C, D. Postoperative 3D image showed reconstruction of the right acetabulum using autologous femoral head structural bone grafting. The graft significantly improved the bone defect in the superolateral acetabular region, significantly enhancing coverage and providing a stable basis for the acetabular prosthesis. Note: CT, computed tomography; DDH, developmental dysplasia of the hip.

lar reamer to further refine its shape, optimizing the fit between the bone graft surface and the prosthetic acetabular cup. To address any potential gaps between the bone graft at the acetabular dome and the host bone bed, an appropriate amount of bone particles and cancellous bone paste were used to enhance stability. After precise positioning of the acetabular cup, the previously placed cancellous bone screws were retightened to ensure a firm fixation. Subsequently, residual autologous bone particles were used to fill the anterior and posterior edges of the bone graft, as well as the junction between the anterior and posterior walls of the acetabulum, further improving the contact and mechanical interlock between the graft and bone bed. This approach provides a favorable biological environment conducive to subsequent bone fusion. Following prosthesis implantation, the surgical wound was closed in layers, and a drain was routinely placed. The surgical procedure is shown in **Figure 2**.

Postoperatively, patients were given standard antibiotic prophylaxis and low-molecular-weight heparin sodium (Jiangsu Wanbang Biopharmaceuticals Co., Ltd., 42004401) was administered starting 8 hours after surgery. As the effects of anesthesia subsided, patients were encouraged to perform active knee and

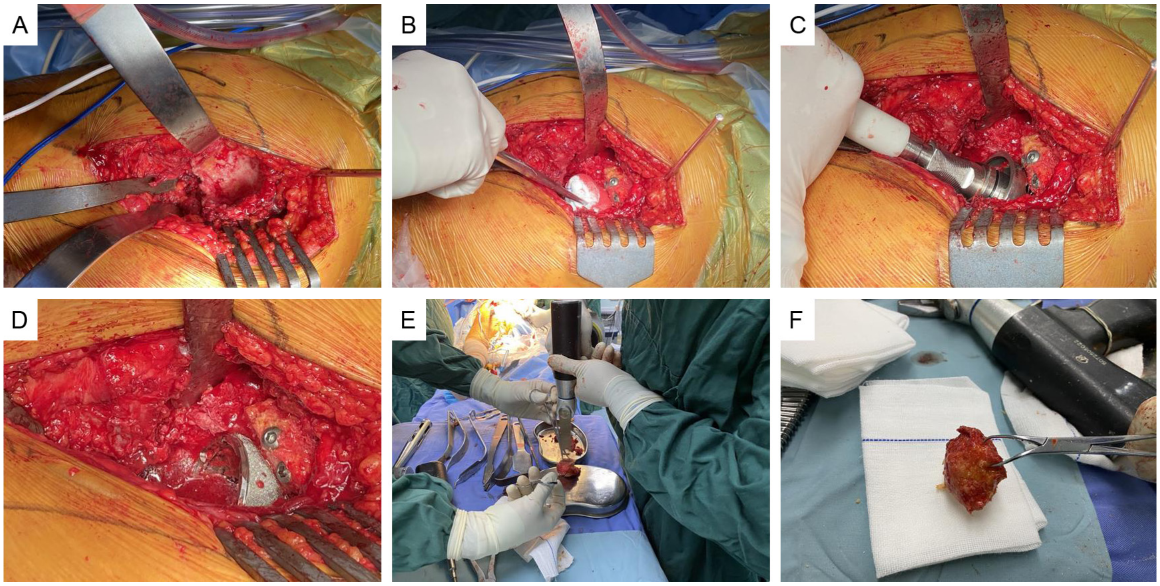

Figure 2. Key intraoperative steps during total hip arthroplasty (THA) assisted by autologous femoral head structural bone grafting. A. Exposure of the acetabulum via the posterolateral approach to evaluate acetabular dysplasia and bone defects; B. Grinding of the acetabulum and identification of the true acetabular position; C. Preparation of the acetabular bed using an acetabular grinder to expose defects within the weight-bearing area; D. Implantation of the processed autologous femoral head graft into the superior lateral acetabular defect for structural reconstruction; E. Harvesting of femoral head tissue following femoral neck osteotomy; F. Preparation of the treated femoral head tissue for structural bone grafting.

ankle flexion and extension exercises. On the first postoperative day, bed-based hip flexion and abduction exercises were initiated, followed by gradual partial weight-bearing training with a walker. Patients were scheduled for radiographic evaluation 1 month post-surgery, with follow-up continuing for 12 months.

Observational indicators

(1) Perioperative indicators [11]: Data were collected on follow-up duration, operative time, intraoperative blood loss, postoperative transfusion volume, and length of hospital stay.

(2) Pain assessment: Pain intensity was evaluated using the Visual Analog Scale (VAS) at preoperative, 1-month postoperative, and final follow-up time points [12]. The VAS score ranges from 0 to 10, with higher scores indicating greater pain severity.

(3) Leg length discrepancy [13]: Changes in leg length discrepancy were measured at preoperative, 1-month postoperative, and final follow-up time points.

(4) Hip joint Range of Motion (ROM) [14]: Hip joint ROM, including flexion/extension, abduction, and internal rotation, was measured at the same time points using a goniometer. Each movement angle was measured three times, and the average value was recorded.

(5) Hip joint function: Functional outcomes were assessed using the Harris Hip Score (HHS) [15] and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) [16] at preoperative, 1-month postoperative, and final follow-up visits. The HHS (maximum 100 points) assesses deformity and function, with higher scores reflecting better hip function. The WOMAC scale (maximum 240 points) evaluates stiffness, functional impairment, and other aspects, where higher scores indicate worse symptoms.

(6) Complications: The incidence of postoperative complications was recorded [17], including hip dislocation, wound healing problems, surgical site infections, lower limb deep vein thrombosis, and periprosthetic infections.

(7) Quality of life: Quality of life was assessed using the General Quality of Life Inventory-74 (GQOLI-74) [18] at the same assessment points. This instrument evaluates four dimen-

Table 1. Preoperative data of 100 adult patients with Crowe type II/III DDH

Indicator	Mean ± standard deviation	Range
Age (years)	53.55 ± 4.19	41-66
Gender		
Male	56	56%
Female	44	44%
Body mass index (kg/m^2)	22.89 ± 2.03	18.66-27.66
Crowe classification		
Type II	39	39%
Type III	61	61%
Difference in length of both lower extremities (cm)	2.88 ± 0.54	-

Note: DDH, developmental dysplasia of the hip.

sions: physical, psychological, emotional, and social functions, each scored out of 100, with higher scores indicating better quality of life.

(8) Radiological evaluation [19]: All patients underwent anteroposterior X-ray examinations preoperatively, on the first postoperative day, at one month, three months, and final follow-up. In some patients, CT three-dimensional reconstruction was performed based on clinical indications to assess acetabular bone defects and prosthesis positioning. Imaging data were independently evaluated by two senior orthopedic surgeons; any discrepancies were resolved through discussion and consensus. The criteria for assessing all imaging parameters were based on the latest orthopedic imaging evaluation guidelines and relevant literature [19]. Each parameter was recorded either quantitatively or categorically, with critical measurements obtained using the PACS system when necessary.

Statistical methods

Data were analyzed using SPSS 23.0 software. Categorical variables, including complication rates, were expressed as percentages and compared using chi-square (χ^2) tests. Continuous variables were expressed as mean ± standard deviation ($\overline{X}$ ± SD). Comparisons of perioperative-related indicators, VAS scores, hip joint ROM, Harris scores, WOMAC scores, and GQOLI-74 scores were conducted. Paired t-tests were applied for within-group comparisons, while repeated measures analysis of variance (ANOVA) was used to analyze data across multiple time points. A *P*-value of < 0.05 was considered statistically significant.

Results

Patient demographics and preoperative data

A total of 100 adult patients with Crowe Type II/III DDH were included in the analysis. The average age was 53.55 ± 4.19 years, with a male-to-female ratio of 56:44. The average body mass index (BMI) was 22.89 ± 2.03 kg/m^2, and the mean preoperative lower limb length discrepancy was 2.88 ± 0.54 cm. According to Crowe classification, 39% of patients were Type II and 61% were Type III (**Table 1**).

Perioperative indicators

All patients successfully underwent surgery and completed the follow-up. Perioperative indicators - including operative duration, intraoperative blood loss, and postoperative transfusion volume - remain within acceptable and controllable limits. Postoperative recovery was favorable, with no severe complications reported (**Table 2**).

Pain level and limb length discrepancy

Compared with preoperative values, both VAS scores and limb length discrepancy were significantly reduced at 1 month postoperatively and at the final follow-up (P < 0.05). This indicates that autologous femoral head structural bone grafting for acetabular reconstruction during THA effectively alleviates pain and reduces limb length discrepancy in adult DDH patients (**Table 3**).

Hip joint range of motion

Compared with preoperative measurements, significant improvements were observed in hip

Table 2. Perioperative indicators of 100 adult patients with Crowe type II/III DDH

Indicator	Range	Mean ± standard deviation
Follow-up period (months)	6-14	10.78 ± 1.65
Operation time (minutes)	92-156	125.12 ± 12.25
Intraoperative blood loss (ml)	230-357	295.32 ± 25.23
Postoperative blood loss (ml)	75-252	185.58 ± 29.74

Note: DDH, developmental dysplasia of the hip.

Table 3. Comparison of pain severity and lower limb length discrepancy before and after surgery ($\overline{X}$ ± SD)

Group	VAS score (points)	Lower extremity length difference (cm)
Pre-op	6.52 ± 2.58	2.88 ± 0.54
1 mo Post-op	3.65 ± 1.62***	1.36 ± 0.44***
Final F/U	1.73 ± 0.73***	0.92 ± 0.23***

Note: Compared with the pre-op, $^{***}P < 0.001$.

joint flexion-extension, abduction, and internal rotation at both 1 month postoperatively and the final follow-up (P < 0.05). These results demonstrate that autologous femoral head structural bone grafting for acetabular reconstruction during THA can effectively improve hip joint mobility in adult DDH patients (**Figure 3**).

Hip joint function

Harris scores significantly increased, while WOMAC scores significantly decreased at 1 month postoperatively and at the final follow-up compared to preoperative values (P < 0.05). This indicates that autologous femoral head structural bone grafting in THA can effectively improve hip joint function in adult DDH patients (**Figure 4**).

Complication incidence

There was one case (1.00%) of postoperative hip dislocation, which was successfully managed with manual reduction and abduction brace immobilization, with no recurrence reported at the final follow-up. All surgical incisions healed by primary intention. No cases of deep vein thrombosis, periprosthetic infection, or other complications were observed.

Quality of life

Compared with preoperative values, the GQOLI-74 scores for physical, psychological, emotional, and social functions were significantly higher at 1 month postoperatively and at the final follow-up (P < 0.05). This suggests that autologous femoral head structural bone grafting for acetabular reconstruction in THA significantly improves the quality of life in adult DDH patients (**Table 4**).

Imaging findings

Radiological follow-up showed stable osseous healing at the femoral neck osteotomy site, the autologous femoral head graft area, and the interface between the acetabulum and the prosthetic cup. Case 1: 1. Aseptic necrosis of the right femoral head. 2. Crowe type III hip dysplasia (right side) (**Figure 5**). Preoperative X-ray images revealed hip joint dysplasia with femoral head dislocation and inadequate acetabular coverage. Postoperative day 1 X-rays confirmed stable fixation of the autologous femoral head graft, secure screw placement, and a well-centered acetabular prosthesis. At 3 months postoperatively, imaging showed maintained prosthesis position, uniform bone density within the grafted area, and no evidence of loosening or displacement. Case 2: 1. Crowe type III hip dysplasia (left side). 2. Aseptic necrosis of the left femoral head (**Figure 6**). Preoperative X-ray images displayed left acetabular dysplasia, high femoral head dislocation, and a shallow acetabulum with bone defects. On postoperative day 3, X-ray images revealed proper prosthesis placement, stable fixation of the autologous femoral head graft reconstructing the superolateral acetabular defect, and satisfactory restoration of the hip joint line.

Discussion

The pathogenesis of adult DDH is complex, involving congenital developmental defects, biomechanical imbalances, and a variety of internal and external contributing factors. Currently, THA remains the gold standard surgical approach for patients with DDH. However, in Crowe Type II/III DDH, significant acetabular bone defects and insufficient superior bony coverage pose considerable challenges to achieving stable fixation of the acetabular

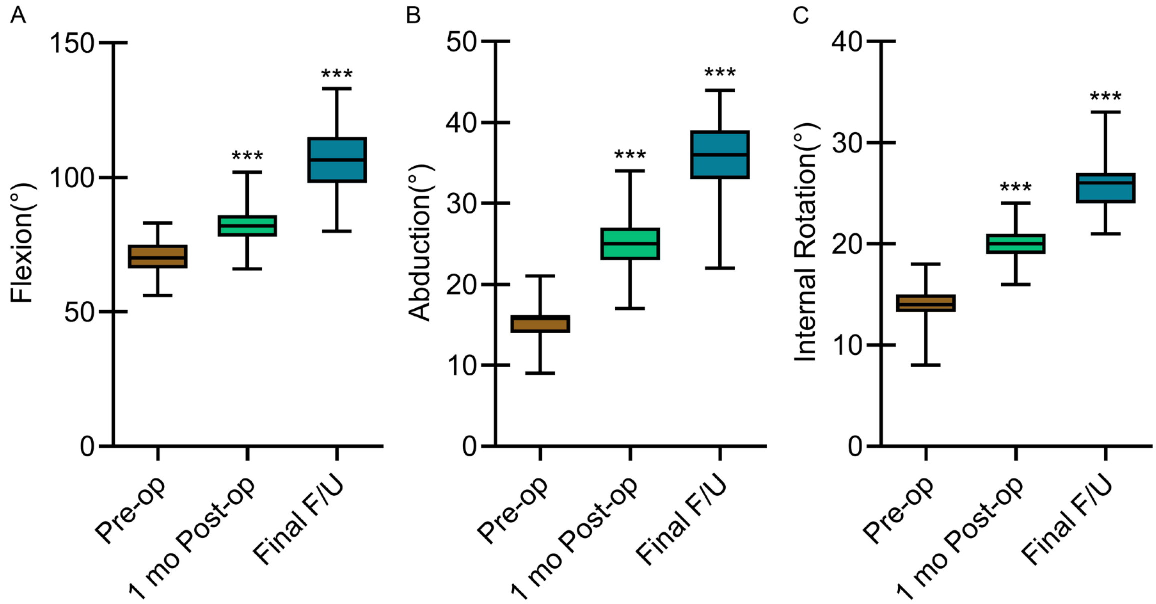

Figure 3. Comparison of hip joint range of motion before and after the surgery in patients. Compared with preoperative measurements, the range of motion in (A) hip flexion and extension, (B) abduction, and (C) internal rotation was significantly increased at one month postoperatively and at the final follow-up. Compared with pre-op, $^{***}P < 0.001$.

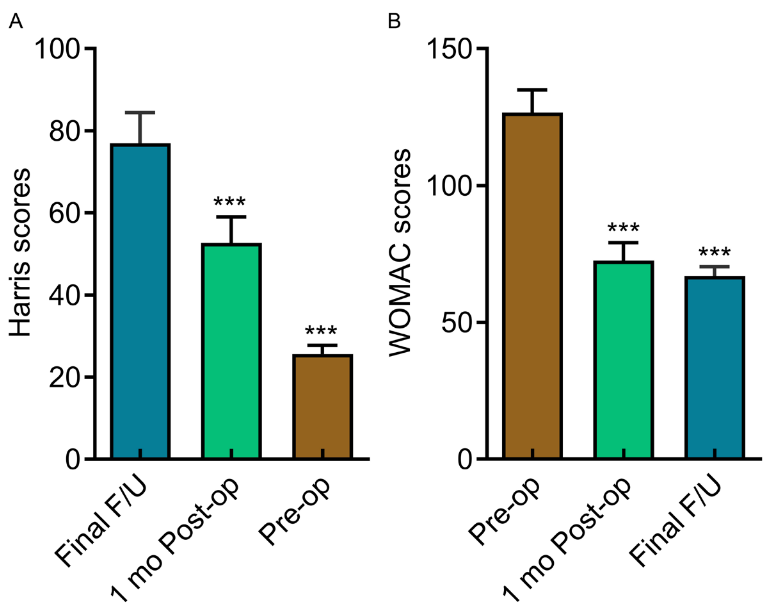

Figure 4. Comparison of hip joint function before and after surgery in patients. Compared with preoperative values, patients showed a significant increase in (A) Harris scores and a significant decrease in (B) WOMAC scores both at 1 month postoperatively and at the final follow-up. Compared with Pre-op, $^{***}P < 0.001$.

component during THA [20, 21]. Recently, metal augments have been widely employed for acetabular reconstruction in THA. Despite their utility, metal blocks often exhibit suboptimal compatibility with the native acetabular bone bed, complicating secure fixation. Although 3D printing technology offers a promising solution by enabling patient-specific implants, its widespread implementation is constrained by high costs and other factors [22]. Alternatively, structural bone grafting using allograft femoral heads has been investigated to facilitate acetabular bone restoration. However, this approach is hindered by issues such as limited mechanical strength, increased risk of infection, and suboptimal graft incorporation and stability [23]. Therefore, overcoming these limitations remains a key focus of clinical research.

In recent years, autograft femoral head structural bone grafting has been increasingly applied for acetabular reconstruction in THA for adult patients with DDH. This approach offers advantages such as surgical simplicity and reliable fixation,

Table 4. Comparison of quality of life of patients before and after surgery (χ±SD, points)

Group	Physical function	Psychological function	Emotional function	Social function
Pre-op	45.26 ± 3.69	50.13 ± 4.03	52.33 ± 4.16	55.15 ± 5.03
1 mo Post-op	62.85 ± 5.77***	65.47 ± 5.12***	66.28 ± 5.62***	67.28 ± 6.18***
Final F/U	74.87 ± 6.38***	76.15 ± 7.15***	75.82 ± 6.05***	80.05 ± 8.33***

Note: Compared with the pre-op, ***P < 0.001.

Figure 5. Case of a 64-year-old female patient with right hip dysplasia (Crowe type III). A. Preoperative hip joint X-ray; B. X-ray on postoperative day 1; C. X-ray at 3 months after the operation.

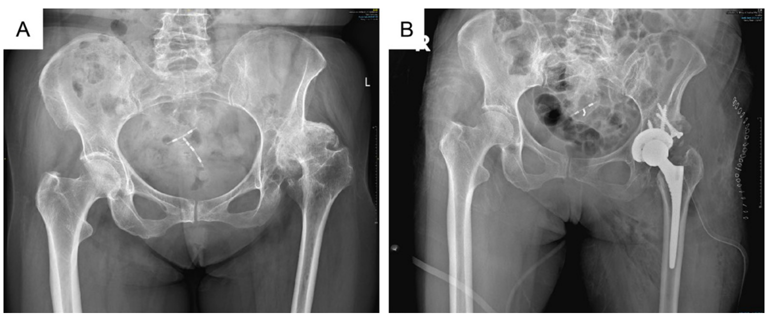

Figure 6. Case of a 67-year-old male patient with left hip dysplasia (Crowe type III). A. Preoperative anteroposterior X-ray of the hip joint; B. X-ray on postoperative day 3 after the operation.

effectively promoting the improvement of hip joint function [24, 25]. Mou et al. reported that autograft femoral head structural bone grafting significantly enhances acetabular prosthesis stability and increases bone stock in Crowe Type III DDH patients, showing notable therapeutic effects [26]. Similarly, Xia et al. confirmed that this grafting method is both effective and safe for Crowe Type IV B DDH patients undergoing THA [27]. Consistent with these findings, the present study revealed significant improvements compared to preoperative values, including reductions in VAS scores, lower limb length discrepancy, and WOMAC scores at 1 month postoperatively and at final follow-up. Additionally, hip joint range of motion - including flexion, extension, abduction, and internal rotation - as well as Harris scores and GQOLI-74 scores across physical, psychological, emotional, and social domains, showed statistically significant increases (P < 0.05). Recent studies have also employed the direct anterior approach (DAA) for total hip arthroplasty (THA), utilizing properly shaped autologous femoral head grafts fixed with screws to reconstruct the acetabulum. This technique effectively addresses the unique bone defects characteristic of Crowe Type III hips and significantly enhances implant cup coverage. Notably, these improvements have been sustained through mid-term follow-up. Moreover, restoration of the physiological center of rotation (COR) of the femoral head has yielded satisfactory outcomes in hip joint function recovery, correction of lower limb length discrepancy (LLD), and alleviation of limping, which aligns well with the findings of the present study. These results suggest that this surgical approach substantially improves both hip function and patients' quality of life. The underlying mechanisms for these benefits may include the following factors: 1. Augmentation of acetabular bone stock: Autologous femoral head structural bone grafting effectively increases bone volume surrounding the acetabulum, providing a robust foundation for prosthesis support and fixation; 2. Restoration of acetabular anatomical anatomy: The graft aids in reconstructing the native acetabular morphology, allowing stable placement of the prosthetic cup within the true acetabulum, thereby improving cup coverage and facilitating restoration of the physiological hip rotation center; 3. Promotion of bone healing: Autologous femoral head grafts possess excellent osteoconductive and osteoinductive properties, enhancing integration between the graft and host bone, which strengthens acetabular stability and ensures long-term prosthesis durability; 4. Improvement of the biomechanical environment: This approach enables accurate anatomical positioning of the acetabular cup, restores physiological load distribution across the hip joint, and reduces prosthesis wear and loosening [28-31]. Imaging follow-up in the current study demonstrated stable osseous union at the subtrochanteric osteotomy site, the autologous femoral head graft area, and the prosthetic socket, further confirming the efficacy and reliability of acetabular reconstruction assisted THA using autologous femoral head structural bone grafting in the treatment of Crowe Type II/III DDH.

In this study, one case of hip dislocation was observed, corresponding to a complication rate of 1.00%. The dislocation was managed with targeted treatment, and no further complications were noted at the final follow-up. These findings suggest that the surgical approach is associated with a low complication rate, demonstrates excellent safety, and contributes positively to patient recovery and prognosis.

Several intraoperative considerations are crucial to optimize outcomes: (1) Removal of hardened bone and scar tissue: During dislocation, localized formation of sclerotic bone and scar tissue often occurs. These tissues exhibit poor biological activity and hinder osseous integration between the graft and host bone. Therefore, prior to bone grafting, thorough debridement of hardened bone and scar tissue in the dislocation area is essential. The bone surface should be meticulously prepared by grinding until fresh, and bleeding cancellar bone is exposed, thereby creating a microenvironment conducive to bone integration. (2) Sequence of bone grafting and cup placement: Bone grafting should precede acetabular cup placement. The subsequent compression exerted by the cup on the graft enhances the compressive forces at the graft-bone interface, which is beneficial for graft incorporation and healing. (3) Use of autologous granular bone: After cup implantation, autologous bone granules can be packed at the junctions between the anterior and posterior edges of the graft and the corresponding walls of the acetabulum. This practice improves graft-to-host bone contact and adhesion, promoting better osteointegration [32, 33].

In conclusion, autologous femoral head structural bone grafting for acetabular reconstruction combined with THA effectively improves hip joint function, promotes quality of life, and is associated with a low complication rate in adult patients with Crowe Type II/III DDH. This treatment represents a safe and reliable surgical option, yielding favorable clinical outcomes and promising mid-term prognoses. However, this study's retrospective design, limited sample size, single-center data source, and relatively short follow-up period restrict the generalizability of the findings. Additionally, the long-term outcomes of this surgical method in adult DDH patients remain to be elucidated. The absence of a contemporaneous control group also introduces potential selection bias. Therefore, future prospective controlled studies are warranted to further validate the efficacy and safety of acetabular reconstruction with autologous femoral head structural grafting in patients with Crowe Type II/III DDH. Moreover, future large-scale, prospective, multicenter studies with extended follow-up are needed for further exploration, ultimately benefiting more adult DDH patients.

Disclosure of conflict of interest

None.

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