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Clinical observation of modified greater trochanteric osteotomy for the treatment of hip dysplasia in adults with high dislocation

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Abstract: *Objective: To investigate the feasibility, perioperative complications and early follow-up effect of modified greater trochanteric osteotomy for the treatment of severe hip dysplasia in adults with high dislocation. Methods: a retrospective analysis in January 2017 - June 2020, the modified sliding femoral greater trochanter osteotomy combined proximal femoral prosthesis handle fixed type of bone cement type and biological acetabulum prosthesis for 14 cases of 15 adult hip dysplasia hips high dislocation severe deformity of patients with primary total hip replacement, 1 case of bilateral, an average follow-up of 18.267±8.876 months. Preoperative X-ray films showed that all patients had unequal length of both lower limbs, small and shallow acetabular development, obvious anterior wall defect, small amount of bone in the acetabular wall, increased femoral neck dry angle and anterior inclination angle, and small and irregular medullary cavity, etc. Clinical and imaging evaluations were conducted for hip joint function, unequal length of both lower limbs, postoperative complications and prosthesis survival rate after surgery. Results: As of the last follow-up, all the patients showed significant improvement in walking ability and pain symptoms after surgery. All the 14 patients with Trendelenburg sign were positive before surgery and all the 15 hips were negative after surgery. All I healing of incision, cut extremities were osseous healing. Before surgery, Harris score was (43.47±7.10) points, and 3 months after surgery, Harris score improved to (87.73±4.23) points, with statistically significant difference (t =-24.16, P < 0.001).The unequal length of both lower extremities before surgery was (3.94±0.88) cm, and the unequal length of both lower extremities was (0.49±0.24) cm 1 day after surgery, the difference was statistically significant (t =15.30, P < 0.001).The WOMAC score was (110.33±7.91) points before surgery, and improved to (61.53±16.77) points 3 months after surgery, with statistically significant difference (t =14.13, P < 0.001). VAS score before surgery was (6.73±1.44) points, and VAS score 3 days after surgery decreased to (1.87±0.92) points, with statistically significant difference (t =17.78, P < 0.001). Conclusion: modified sliding femoral greater trochanter osteotomy restored in the hip muscle tone, before the reconstruction of the lateral femoral physiological eccentricity and inclination, restored the relative length and lower limb soft tissue tension, reduce the risk of cutting after bone fracture healing, the femoral handle initial stability is good, treatment is one of the effective operation of high dislocation of adult hip dysplasia.*

Keywords: *Total hip arthroplasty; Adult hip dysplasia; Slip osteotomy*

1. Introduction

Total hip arthroplasty (THA) in the treatment of Crowe IV hyperdislocation of the hip (DDH) in adult hip dysplasia is difficult[1], especially the exposure of the hip is one of the biggest difficulties. The acetabulum patients develop small and shallow, anterior wall defect less obviously, mortar wall bone and joint capsule redundant fat, anatomical level mixed and femoral neck stem angle and the angle increases exceedingly fine, proximal medullary cavity and irregular, etc., and with a double lower limbs before long, often implant placement position is not ideal, the joints surgeon is a challenge, also has been a lack

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of an effective clinical treatment[2]. The technique of greater trochanteric osteotomy, first proposed by Charnley, is very effective in assisting the exposure of the hip joint. However, the osteotomy method at that time had a high incidence of complications, including increased blood loss and operation time, as well as nonunion of the osteotomy site, with a nonunion rate even as high as 37.5%[3]. In 1972, Glassman et al. proposed the great trochanteric sliding osteotomy, which has the advantage that the soft tissue sleeves on both sides are retained while osteotomy, which can ensure good bone healing without damaging coupling[4,5].This bone cutting technology was widely used in complex revision hip replacement, and complex acetabulum fracture surgery, good results were obtained[6,7], but for the treatment of adult hip dysplasia, few reports of high dislocation recently the authors try to improve the femoral greater trochanter high dislocation glide osteotomy treatment of adult hip dysplasia, satisfactory early clinical curative effect and the imaging results, the report is as follows.

2. Materials and methods

2.1 General Information

Retrospective analysis from January 2017 to June 2020, 14 patients with 15 hip Crowe IV high dislocation adults with severe hip dysplasia were treated with modified greater trochanteric sliding osteotomy, proximal fixed non-bone cement femoral prosthesis handle and biological acetabular prosthesis. There were 2 males (2 hips), 12 females (13 hips), 8 females (8 hips), and 7 patients (7 hips) in the left hip, among which 1 patient was treated with bilateral stage replacement, aged 22-53 years, with an average age of (36.67±10.38) years.

Inclusion criteria : (1)Hip dysplasia in adults with high dislocation of Crowe IV type, patients with limited mobility, claudication and joint pain should undergo THA; (2)Initial THA, unilateral or bilateral staging replacement; (3)Acetabular development is small and shallow, anterior wall defect is obvious, acetabular wall bone amount is small; (4)Shortening of the affected limb of the greater trochanter accompanied by abnormal morphology of the proximal femoral medullary cavity, such as closed medullary cavity, narrowing, angulation or rotation; Femoral neck shortening, varus or varus; Anteriorly dip abnormal etc (Tab. 1).

Exclusion criteria: (1) Severe underlying medical diseases that cannot tolerate surgery; (2) Tumor or infection of hip joint; (3) Revision of hip joint; (4) poor compliance, can not cooperate with the treatment; (5) Patients who lost follow-up (Tab. 1).

Tab.1 Patient inclusion and exclusion criteria

Criteria	Details
Inclusion criteria	Hip dysplasia in adults with high dislocation of Crowe IV type, patients with limited mobility, claudication and joint pain should undergo THA;
	Initial THA, unilateral or bilateral staging replacement;
	Acetabular development is small and shallow, anterior wall defect is obvious, acetabular wall bone amount is small;
	Shortening of the affected limb of the greater trochanter accompanied by abnormal morphology of the proximal femoral medullary cavity, such as closed medullary cavity, narrowing, angulation or rotation; Femoral neck shortening, varus or varus; Anteriorly dip abnormal etc.
Exclusion criteria	Severe underlying medical diseases that cannot tolerate surgery;
	Tumor or infection of hip joint;
	Revision of hip joint;
	poor compliance, can not cooperate with the treatment;
	Patients who lost follow-up.

None of the patients received traction before surgery. Preoperative clinical evaluation, 3 months postoperatively, and the latest follow-up Harris hip score and WOMAC score were performed for all the patients. The preoperative Harris hip score was (43.47±7.10) points, with obvious shortening of the affected limb, and the preoperative length of both lower limbs was (3.94±0.88) cm, preoperative WOMAC score was (110.33±7.91) points, and preoperative VAS score was (6.73±1.44) points.

2.2 Preoperative planning

Preoperative X-ray template measurement was performed, and orthotopic pelvic, lateral hip and

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lumbar X-ray images were collected. CT plain scan and three-dimensional reconstruction were performed on the upper and middle 1/3 of the hip joint and the femur, so as to determine the size of the acetabulum, proximal femoral deformity and abnormal development, and to help select the false body size. When the patient was standing, wood blocks of different heights (e.g. 1.0, 2.0, 3.0, and 4.0cm) were placed until the pelvis was in balance, and the distance from the anterior superior iliac crest to the tip of the medial malleolus was measured to compare the absolute and relative lengths of both lower limbs. In young patients, lumbar spine flexibility was good, and the length difference of both lower limbs was completely corrected to achieve absolute equal length of both lower limbs. Older patients have a stiff spine and try to keep both lower limbs relatively equal length[8].

2.3 Surgical methods

After successful anesthesia, the patient was placed in the lateral position, the wound was pasted to close the perineum, the skin of the surgical area was disinfected with iodine and alcohol, and the sterile sheet was laid. The posterolateral approach was used to cut the skin and subcutaneous tissue layer by layer, and the contracture synovial membrane, scar granulation tissue and joint capsule around the hip joint were completely released during the operation, including external rotation muscle group, iliopsoas, adductor muscle, iliotibial band and gluteus maximus insertion point, etc., to expose and protect the sciatic nerve. During the operation, the hip joint was intended to be exposed, but it was often accompanied by rigidity of the hip joint, so full exposure was difficult. A long oblique bone about 8-10cm long, with a width of 1/2 of the proximal circumferential shaft diameter, was made from the piriform fossa obtuse below the greater trochanter and a stop 3-4cm below the lesser trochanter. The coronal plane retained the continuity and integrity of the gluteus medius and moved the osteotomy forward to expose the acetabulum. C-arm fluoroscopy was used to determine the location of the acetabulum, and the acetabulum was formed by grinding the acetabular forming file in turn. The preliminary fixation was relatively stable according to the mold test of acetabular prosthesis. In case of bone defect at the top of the acetabulum seen by c-arm fluoroscopy, the femoral neck was removed for repair and cartilage removal, then placed at the bone defect site, and fixed with 2-3 screws. The biotype acetabular prosthesis was taken, and the acetabular prosthesis was inserted into the formed acetabular with an outspread of 40 °- 45 °and a forward tilt of 15 °- 20 °. The initial test was stable, and 2 screws were implanted above the acetabular head for strengthened fixation. The posterior acetabulum is pressurized with a ceramic or polyethylene liner. According to the soft tissue tension around the hip joint, the rotation center of the acetabular side, and the difference in the length of both lower limbs, and according to the preoperative plan of 1-3cm below the lower trochanter, 1 or 2 steel wires were pre-bound below the osteotomy line to prevent the fracture end from being broken and displaced during the pulp cavity file reaming. The anterior inclination of the femoral prosthesis was adjusted according to the anterior inclination of the acetabular cup, and the prosthesis test model and the standard femoral neck length were placed by gradually expanding the medulla. The tension, stability and mobility of the sciatic nerve and soft tissue were examined, and whether secondary osteotomy and further release of soft tissue were required. To satisfy the stability of the test mode, the biological femoral prosthesis handle was placed after rinsed, and the internal side of the sliding osteotomy block was modified to make the femoral prosthesis handle shoulder anastomosis with the internal surface of the reduced osteotomy block. The greater trochanter of the femur was transferred downward to reconstruct the gluteal medius muscle tension and eccentricity. The osteotomy was fixed with 3-4 double-stranded steel wire rings, and autologous cancellous bone graft was used in the suture. Install the femoral head model to reset the hip joint. Check for good stability in all directions, no tendency to dislocation, and whether the limbs of both lower limbs are equal in length. The incision was thoroughly rinsed, no active bleeding was detected, after the gauze and instruments were checked, the drainage tube was placed, the gluteus maximus stopping point was sutured, and the wound was closed layer by layer. In this group, biomorphic rectangular or conical straight stalks were fixed proximally, most of which were small ones, to adapt to the proximal femur with abnormal development (Fig.1).

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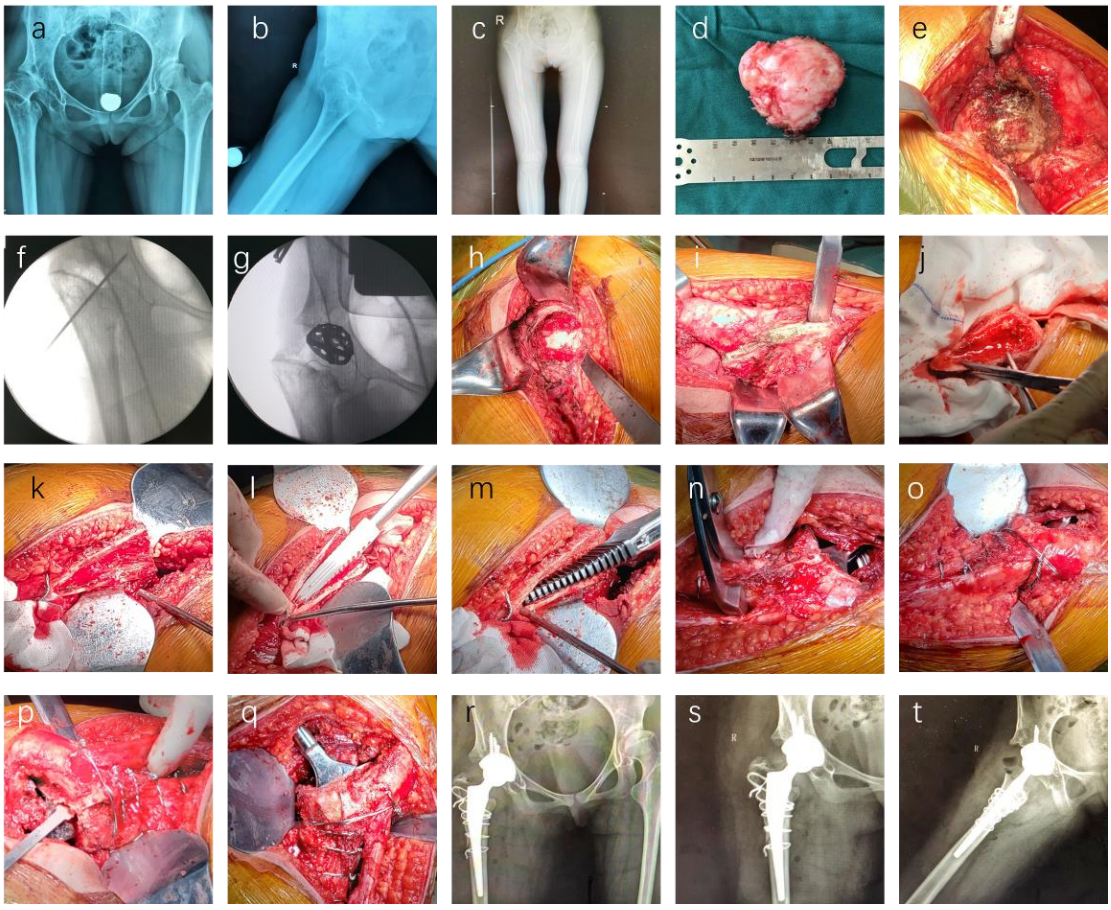

Fig.1:Detailed surgical procedure of modified greater trochanteric osteotomy for the treatment of hip dysplasia in adults with high dislocation

2.4 Postoperative treatment

If the initial stability of intraoperative pressure distribution was good, the patient moved the affected limb without weight on the first day after the operation. Within 6 weeks after the operation, avoid active abduction of affected limb, and help both crutches without weight bearing; Within 6-12 weeks after the operation, lift the affected limb of both crutches to carry weight.3 to 6 months after the operation, according to the X-ray fracture healing status, decide whether to abandon crustings and fully load.

2.5 Efficacy evaluation index

The functional and imaging data of the patients before, 1 day, 3 months after surgery, and at the last follow-up were evaluated, as well as the surgical complications (infection, dislocation of the prosthesis, periprosthesis fracture, prosthesis loosening, deep venous thrombosis of the lower extremity, ectopic ossification, vascular and nerve injury, and different length of the lower extremity). The clinical function of hip joint was evaluated by Harris score and WOMAC osteoarthritis score scale. VAS score was used to assess the degree of pain improvement in low back pain. Trendelenburg sign was used to assess abductor strength, and the length of both lower limbs was measured by connecting the anterior superior iliac spine to the tip of the medial malleolus. Postoperative imaging assessment of aseptic loosening of the prosthesis was performed using Gruen and Charnley methods. If the acetabular cup moved >5 °or b> 3 mm compared with the first postoperative X-ray, the acetabular cup shifted; The distance between the shaft shoulder and the tip of the greater trochanter was measured, and compared with the first postoperative X-ray, if the displacement of >4 mm was the subsidence of the shaft, and the healing of the greater trochanter slip osteotomy block was evaluated.

2.6 Statistical Treatment

The data were expressed as mean ± standard deviation. SPSS 21.0 software package was used for

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statistical analysis. Kolmogorov-smirnov test and Shapro-Wilk test were used to evaluate the normality of the data, and Wilcoxon rank sum test was used to evaluate the differences in Harris score, WOMAC score and VAS score. Comparison between groups was performed by paired T test, and $P \leq 0.05$ was considered statistically significant.

3. Results

3.1 Postoperative early complications and score

No infection among the patients, class a healing incision were I period. Two patients presented with transient sciatic nerve palsy and recovered completely after 6-8 weeks. There was no postoperative dislocation of hip joint in 1 case. The unequal length of both lower extremities before surgery was (3.94±0.88) cm, and the unequal length of both lower extremities was (0.49±0.24) cm 1 day after surgery, the difference was statistically significant ($t = 15.30$, $P < 0.001$). VAS score before surgery was (6.73±1.44) points, and VAS score 3 days after surgery decreased to (1.87±0.92) points, with statistically significant difference ($t = 17.78$, $P < 0.001$) (Tab. 2).

Tab. 2 Preoperative/postoperative clinical evaluation results of 14 patients

Case	Gender	Age	Surgical history	Follow-up (month)	T sign Pre/post	HHS pre/post	LLD pre/post	WOMAC pre/post	VAS pre/post
1	Female	28	no	34	Positive/negative	35/81	4.7/0.6	105/70	8/3
2	Female	26	no	32	Positive/negative	38/78	3.5/1.1	113/73	7/2
3	Female	25	yes	26	Positive/negative	40/83	4.3/0.8	98/59	5/2
4	Female	28	no	25	Positive/negative	36/89	2.7/0.4	125/69	7/3
5	Female	22	no	23	Positive/negative	43/88	2.8/0.2	117/66	6/2
6	male	30	no	23	Positive/negative	63/89	4.6/0.3	109/54	6/2
7	Female	27	yes	19	Positive/negative	50/86	4.9/0.7	99/50	9/3
8	Female	46	no	18	Positive/negative	45/93	5.1/0.4	108/52	8/2
9	Female	53	no	17	Positive/negative	42/86	3.2/0.3	113/77	9/2
10	male	40	no	16	Positive/negative	38/92	4.4/0.2	102/68	7/1
11	Female	49	no	9	Positive/negative	43/90	3.7/0.5	117/72	5/0
12	Female	46	no	9	Positive/negative	42/91	5.4/0.5	110/70	6/2
13a	Female	45	no	8	Positive/negative	43/89	3.2/0.5	118/69	7/2
14a	Female	45	no	8	Positive/negative	42/91	3.2/0.5	118/69	7/2
15	Female	40	yes	7	Positive/negative	52/90	3.4/0.3	103/55	4/0

3.2 Late postoperative complications and functional scores

All the 14 cases of hip Trendelenburg sign were positive before surgery and negative after surgery. Three months after surgery, Harris score and WOMAC score improved to (87.73±4.23) points and (61.53±16.77) points, both of which were statistically significant compared with those before surgery ($t = -24.16$, $P < 0.001$; $t = 14.13$, $P < 0.001$) (Tab. 2).

3.3 Imaging assessment

The common complications of modified greater trochanteric osteotomy include nonunion or delayed union, decreased rotatory stability. The rotation stability of femur stalk is mainly related to the cross-section geometry of the femur component. In addition, our study found that all the 14 patients with 15 hips were followed up for (18.27±8.88) months (7-34 months) on average. Postoperative follow-up X-ray showed that the acetabulum was located in the acetabulum region. At the last follow-up, the imaging evaluation showed that the femoral and acetabular prostheses in all cases obtained bone growth fixation. The osteotomy ends were all bony union, and the fracture healing time was 3-6 months. At 4 months after the operation, the fracture was basically healed, and at 6 months after the operation, all the trochanteric slip bone blocks of the femur had no displacement in bone healing. No osteolysis was found around the femoral or acetabular prosthesis, and no prosthesis loosening was observed. (Fig.2).

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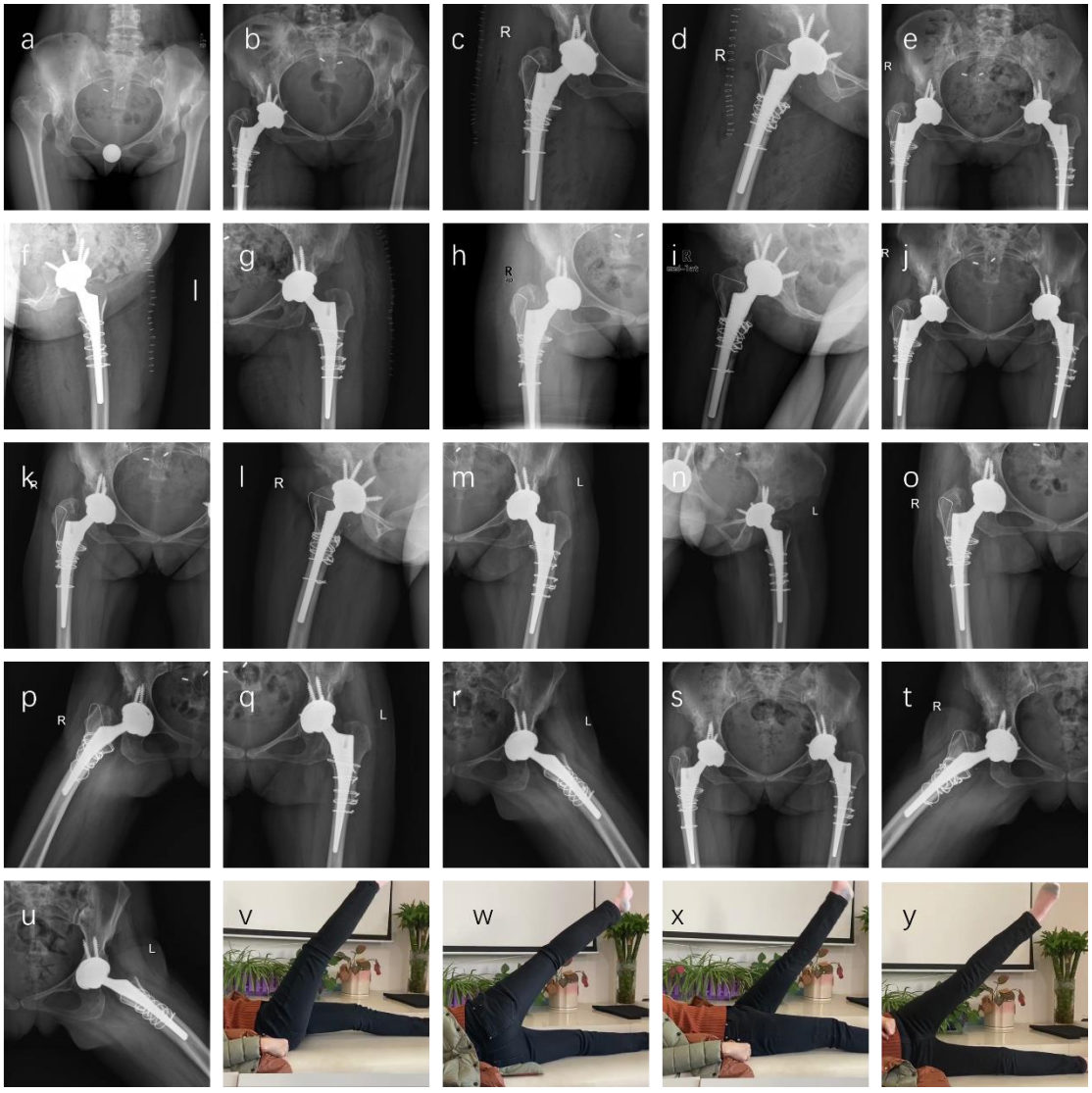

Fig.2 Follow-up X-ray and joint function results of modified greater trochanteric osteotomy for the treatment of bilateral high dislocation of hip dysplasia in adults

4. Discussion

The etiology of adult hip dysplasia is various and the deformity is complex and changeable. The femoral head causes secondary changes in anteriorly angle, cervical trunk angle and medullary cavity due to lack of stable restraint. In patients with unilateral disease, bilateral limb length difference and affected limb shortening were particularly obvious, and with the aggravation of femoral head dislocation, proximal femoral deformity was also continuously aggravated, especially Crowe IV type[9]. These diseases are often associated with femoral neck and neck dry angle variation, such as shortening or pronation; The anteriorly dip angle increases abnormally; The proximal medullary cavity is closed, curved and twisted. Abnormal proximal femoral eccentricity and gluteal medialis tension; Scar contracture of the ligaments around the proximal joint; Secondary lumbar scoliosis and knee pronation with unequal length of both lower limbs[10].

At present, artificial hip replacement is the most effective way to treat adult hip dysplasia, which has a good clinical effect in improving hip function and relieving pain[11-12]. However, adult hip dysplasia in patients with hip surrounding soft tissue condition is very poor, hip in fixed position for a long time, in the joint capsule, buttocks muscles, the iliotibial band and the muscle of many structure of soft tissue contracture or atrophy, and loss of normal, greatly increasing the difficulty of operation, at the same time, the risk of sciatic nerve and femoral nerve injury more than ordinary hip replacement.

The choice of surgical approach is very important for adult hip dysplasia. At present most scholars

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prefer to using posterolateral approach to expose, but indeed will encounter in the process of exposing the femoral bone cutting view show difficult issues, the big rotor slip osteotomy is a good choice, under the limited additional trauma, to shorten the operation time, convenient vision exposed operation purpose.

Transverse greater trochanter osteotomy, widely used for revision hip arthroplasty and complex primary hip replacement, has been abandoned due to its high incidence of complications[13-14]. The main problem with this technique is the non-union of the osteotomy and the resulting instability of the hip. By preserving the continuity of abductor group, greater trochanteric osteotomy and vastus lateralis muscle, the greater trochanteric osteotomy technique effectively prevents proximal displacement of the greater trochanter, thus greatly reducing the rate of bone nonunion. Bhan et al. believe that for patients with ankylosis of external flexion of the hip joint, greater trochanter osteotomy can increase the risk of exposing and avoiding injury to the gluteus medius and gluteus minimus[15]. On this basis, some scholars used the modified great trochanter sliding osteotomy to retain the posterior external rotator group and the bone part of the joint capsule insertion, thus making the posterior structure more stable[16].

Improved techniques for sliding femoral greater trochanter osteotomy features: high dislocation of adult hip dysplasia before the processing of proximal femoral deformities are choose according to femoral deformities form at the bottom of the femoral handle, such as the hip handle, S-ROM matched stack femoral prosthesis handle, adjustable neck stem angle of proximal femoral handle fixed type, etc., all reconstructive surgery is through the prosthesis to adapt to the shape of the medullary cavity, in postoperative patients with hip muscle tension, eccentricity and the medullary cavity formation of proximal femoral torsion did not recover[17]. The surgical team of the author used the greater trochanteric slip osteotomy technique of Paavilainen and xi-fu Shang for reference, and changed the vertical osteotomy into long oblique osteotomy with a width about 1/2 of the proximal diaphyseal circumference, which not only increased the contact surface and stability of the osteotomy with the host bone, but also reduced the probability of fracture nonunion[18,19]. At the same time, after osteotomy, the medullary cavity is thoroughly exposed to facilitate the removal of the original, including the femoral neck, greater trochanter, metaphyseal, femoral shaft proximal various types of angular and rotative malformations, and through the femoral lesser trochanter or subtrochanteric osteotomy to greatly increase the adjustment space of limb length.

In order to perform abductor function and enhance stability of hip joint after total hip replacement, proper fixation of the greater trochanteric slip osteotomy is very important. The downward displacement distance shall be based on the vertex of the great trocar lower than the reconstructed hip center, combined with the eccentricity of the healthy side and the cervical dry angle[20-21]. However, Crowe IV DDH patients have severe femur abnormalities that make it difficult to use the common standard femoral stalk. reasonable selection of femoral prosthesis is more important. Most of the literatures recommend the application of the assembled femoral shaft. Although the assembled femoral shaft has many advantages, it is difficult to avoid the wear, corrosion, fracture and other complications at the metal joint, and it is expensive. However, in Chinese patients with Crowe IV DDH, the femoral medullary cavity is thinner, and the assembled prosthesis may not be the most ideal prosthesis. It has been reported that the application of Zimmer femoral trumpet handle has achieved good clinical effects, but the intraoperative fracture rate is as high as 26.6%, which increases the incidence of surgical complications. We used the STAR JOINT WE-lock hydroxyapatite fully coated femoral stalk. At the same time, the author's surgical team adopted the four-strand semi-parallel wire binding method. The single wire was thick and 1.5mm in diameter to avoid cutting fractures or unstable fixation. For local bone defects, femoral head and cancellous bone graft could be used to reduce the probability of non-healing[22-23]. Lakstein et al. found that the osteotomy healing rate was 95.2% in 142 patients undergoing greater trochanteric slip osteotomy in a follow-up of more than 3 years[24]. However, Wieser et al. found that age and bone cement prosthesis were the main risk factors for non-union of greater trochanteric osteotomy in their assessment of risk factors[25]. In our study, there were no cases of bone nonunion due to the limited follow-up time and number of cases.

Because the medullary cavity is often dysplastic in these patients, a small rectangular or conical proximal femoral prosthesis handle is recommended. The distal end of the stem generally needs to exceed the distal end of the sliding osteotomy plane by 3-4cm, that is, the diameter of the medullary cavity at the distal end of the osteotomy plane by twice as much as the diameter of the medullary cavity at the distal end of the osteotomy plane, and the distal end of the medullary cavity should be inserted and fixed by longitudinal compression. When the femoral prosthesis stalk is inserted, excessive anterior-angle and medullary cavity torsion should be corrected to reshape the morphology of proximal medullary cavity. If the proximal medullary cavity is closed and thinned, the distal medullary cavity can be split longitudinally and the wire can be prebound. As long as the pressure allocation is satisfactory when the

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prosthesis is inserted, the initial stability of the femoral stem will not be affected[26].

In addition, Lakstein et al[27]. reported that the most common complication of greater trochanteric sliding osteotomy was persistent greater trochanteric regional pain, with an incidence of 15.6%, but only a few patients needed surgery to remove the greater trochanteric internal fixation. In our study, there were no cases of persistent pain. On the contrary, 2 cases presented transient manifestations of sciatic nerve palsy, but the patients recovered completely 6-8 weeks after the operation.

(1)This study did not set up a control group and the sample size was small. The conclusions reached have yet to be verified by the long-term follow-up results. In view of the rare occurrence of such patients and the time-consuming case accumulation, the existing results are reported; (2)There is a certain time span for this study, and the technical maturity of the surgical team is different, which may also have a certain impact on the surgical results.

In summary, the improved greater trochanteric slip osteotomy was used to reconstruct the lateral femoral physiological eccentricity, cervical trunk angle and antegrade inclination, and to restore the relative length and soft tissue tension of the lower extremity to the maximum extent. Conventional proximal fixation femoral prosthesis handle is combined with multi-strand wire loop ligation to ensure the initial stability of hip prosthesis, reduce the risk of post-osteotomy fracture nonunion and sciatic nerve injury, with low cost and low complications, and is suitable for the treatment of hip dysplasia in adults with high dislocation.

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