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Original Article

Titanium trabecular metal acetabular components and S-ROM prosthesis with subtrochanteric osteotomy for treating Crowe IV developmental dysplasia of the hip

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Abstract: Objective: The goal of this study was to analyze the curative effect of titanium trabecular metal (TM) acetabular components and S-ROM prosthesis total hip replacement combined with subtrochanteric osteotomy for the treatment of Crowe IV developmental dysplasia of the hip (DDH). Methods: The TM acetabular components and S-ROM prosthesis combined with subtrochanteric osteotomy total hip replacement were utilized for the treatment of 12 adults (12 hips) with Crowe IV DDH. The short-term curative effect was evaluated using Harris score of hip function, osteotomized bone and limb extension lengths, visual analog scale (VAS) of femoral region, and radiography. Results: The patients were followed up for an average of 28 months. The VAS was significantly lower than that before surgery (P<0.05). The Harris score improved significantly from preoperative to postoperative (P<0.05). Furthermore, the VAS score of the femoral region was improved. Preoperatively, the limb was shortened and the bone was resected intraoperatively, and the limb was extended postoperatively. The postoperative X-ray showed that the acetabular cup was in the position of the true acetabulum, the hip prosthesis-bone interface was stable without loosening. The patients undergoing osteotomy under the femoral trochanter achieved bony union after 6 months. None of the cases required prosthesis revision during the follow-up. Conclusion: TM acetabular components and S-ROM prosthesis combined with subtrochanteric osteotomy total hip replacement are effective in the treatment of patients with Crowe IV DDH. It can resolve the anatomical variation of hip development and improve the joint function, thereby improving the quality of life of patients.

Keywords: TM acetabular components, S-ROM prosthesis, subtrochanteric osteotomy, Crowe IV developmental dysplasia of the hip, total hip replacement

Introduction

Crowe IV is the most severe among the adult developmental dysplasia of the hip (DDH) disorders. Artificial hip replacement is an effective method for the treatment of such diseases. Nevertheless, Crowe IV DDH patients suffer from acetabulum dysplasia and require a satisfactory healing of the prosthesis with the surrounding bone bed after reconstruction of the preinvasive acetabulum [1]. Trabecular metal (TM) acetabular cup promotes the osseo-integration of the bone for an efficient fixation [2]. Moreover, the modular Sivash-range of motion (S-ROM) femoral prosthesis exhibits a proximal cuff and a distal ridge to prevent rotation as well as an adjustable anteversion angle. These structural conformations can correct the developmental dysplasia of proximal femur in patients with Crowe IV DDH effectively, and achieve the initial stability of the femoral prosthesis-bone interface. Subtrochanteric osteotomy can evade vascular and nerve injury due to an excessive downward migration of the hip rotation center in DDH patients with a high degree of dislocation [3-5]. In this study, the TM acetabular components and S-ROM prosthesis were combined with subtrochanteric osteotomy for the treatment of 12 adults (12 hips) with Crowe IV DDH between June 2012 and 2017 and achieved satisfactory results.

Clinical data

General information

A total of 12 patients (12 hips), aged 38-64 (mean age, 47 years) were selected. The cohort comprised of 2 males and 10 females; 5 cases of left hip and 7 cases of right hip belonged to Crowe type IV. X-ray scans showed a complete dislocation of the femoral head, as well as developmental dysplasia of acetabulum and proximal femur. All the patients manifested secondary osteoarthritis. The affected limbs were shortened by 3.7-6.2 (average, 4.8 cm). The average Harris score of the hip joints was 41.6 ± 9.8 points.

Preoperative preparation

Preoperatively, all patients underwent anteroposterior radiography of pelvis, as well as anteroposterior and lateral radiography of the middle-and-upper segment of the femur to elucidate the acetabular and femoral development, the involution relationship between the femoral head and acetabulum, the severity of dislocation, the presence of anteroposterior, lateral, and rotational deformities of the femur, and the development of the femoral medullary cavity and anteversion of the femoral neck for an appropriate selection of the type and model of the femoral stem [4]. Subsequently, the three-dimensional the hip joint was reconstructed based on the CT scanning images to identify the location of the true and false acetabulum as well as the bone mass of each acetabular wall and determine the deformity degree of the acetabulum and proximal femur as well as the location, size, and depth of the true acetabulum.

Surgical methods

After successful epidural anesthesia, patients were placed in a lateral position with a conventional drape, following which, an incision was made at the posterolateral hip joint. The extorter muscle group was sliced while protecting the gluteus medius muscle, in order to expose the articular capsule. Then, the soft tissue surrounding the hip was appropriately released to expose the femoral head and neck, followed by femoral neck osteotomy. The inferior and posterior areas of the false acetabulum were scoured to identify the true acetabulum. After removal of the soft tissue from inside and surrounding the true acetabulum, an ultra-small acetabular file was used for filing the true acetabulum while preserving the thickness of the anterior and posterior acetabular wall. First, the bottom of the acetabulum was filed, during which, the filing of the posterior-superior side entering into the false acetabulum was avoided, with a depth up to the inner plate of the acetabular base, in order to further enlarge the acetabulum. Finally, anti-filing was performed using the acetabular file to expand the acetabulum by compacting the bone mass, followed by implantation of an acetabular cup with a 40-46 mm diameter. The pulp chamber was opened at the proximal femur, while a medullary file was used for reaming. Then, the osteotomy was transversely conducted at 2 cm below the small rotor, and a testing mold was installed to reset the hip joint. Subsequently, the distal limbs were tracted until the lower extremities had the same length, the distal femur that was superimposed with the proximal femur was cut off using a pendulum saw, followed by withdrawal of the testing mold and implantation of the S-ROM femoral prosthesis for restoring the hip joint. The stability of the hip joint was confirmed, and the resected surface was encircled with the cut-off cortical bone plate and tied with steel wires, followed by layer-interrupted suture to close the incision. In this study, the cementless prosthesis was selected, the acetabular cup was TM acetabular cup (Johnson & Johnson, USA) and polyethylene lined, and the femoral stem prosthesis was S-ROM prosthesis (Johnson & Johnson, USA).

Postoperative treatment

Postoperative patients were administered prophylactic antibiotics for 48 hours and subcutaneously injected with low molecular weight heparin to prevent deep vein thrombosis in lower extremities. After surgery, the patients were required to maintain hip abduction of 20-30° and flexion of 30-45°. The femoral and sciatic nerve functions were checked immediately after recovery from anesthesia. In cases with knee extension weakness and thigh numbness, femoral nerve injury was probably, which required increasing the hip flexion angle and fixation with adjustable hip abduction brace. In cases with the weakness of foot and ankle dorsiflexion as well as calf numbness,

Table 1. Clinical data of 12 cases of Crowe type IV developmental dysplasia of the hip

Patient Number	Sex	Side	Age	LOFR	HSS		LD	
					Preop	Postop	Preop	Postop
1	Female	Left	44	4.3	34	92	3.4	-1.2
2	Female	Right	56	3.7	45	86	2.6	-0.5
3	Female	Left	47	5.4	28	71	3.6	0.5
4	Female	Right	62	4.0	49	82	2.0	0.4
5	Female	Right	39	5.2	56	90	4.0	0.0
6	Female	Right	64	4.8	43	82	2.9	-0.9
7	Female	Left	39	5.3	34	72	3.8	-1.4
8	Male	Left	56	5.6	36	76	4.0	-1.8
9	Female	Right	38	5.8	54	81	2.8	0.0
10	Female	Right	39	4.6	56	69	3.0	-0.6
11	Male	Left	42	3.9	30	89	1.6	-0.8
12	Female	Right	46	5.0	34	87	3.5	-1.0

LOFR, length of femoral resection; HHS, Harris hip scores; LD, leg discrepancy; Preop, pre-operation; Postop, post-operation.

sciatic nerve injury was possible, which required increasing the knee flexion angle. The drainage tube was removed at postoperative 48 hours, and the hip joint was reviewed by radiography. In addition, the level of C-reactive protein (CRP) and blood sedimentation were monitored regularly. From the day 1 post-surgery, the patients were instructed to practice ankle flexion and extension as well as quadriceps isotonic contraction. Two weeks after surgery, the patients could walk with crutches. Subsequently, these patients were regularly reviewed by radiography at postoperative 3 months, 6 months, and every year after that. According to the X-ray review results, the load was increased gradually until the patients could move around without crutches after the bone union was completely achieved in the resected region.

Statistical analysis

Statistical analyses were performed using SPSS17.0 software. Data are expressed as mean ± standard deviation. Preoperative and postoperative data were compared using paired t-test with an inspection level α=0.05.

Results

All incisions healed by first intension, and patients in none of the cases suffered from the dislocation of the hip joint and sciatic nerve injury. However, 2 cases presented femoral nerve paralysis but were recovered automatically after 6 months. The postoperative color Doppler flow imaging identified 1 case of asymptomatic muscular venous thrombosis in lower extremities. All patients were followed up for 1-4 years, with a mean duration of 28 months. Four cases suffered from mild limp that was significantly improved as compared to that before the surgery; the daily life was restored. At postoperative 6 months, the length of the diseased limb was -1.8-0.5 cm different from that of the healthy limb with a mean difference of -0.6 cm. The Harris score of the hip joint was 81.4±7.5 points (**Table 1**), which showed a significant difference as compared to that before surgery (t=1.77, P=0.00). X-ray imaging showed that the resected region of the femur healed at postoperative 3-6 months with the stable acetabular prosthesis-bone interface (**Figure 1A-H**). None of the cases required prosthesis revision during the follow-up.

Discussion

Treatment of acetabulum

Crowe IV DDH in adults is a severe hip deformity. Total hip replacement is an effective method for the treatment of Crowe IV hip dysplasia. However, this surgical method is complicated, requires a prolonged procedure, and has a high incidence of postoperative complications [6].

The true acetabulum is stunted or even loses the shape of the acetabulum, which is extremely small and superficially developed, manifested as triangular fossa with a thin anterior wall. Nonetheless, the true acetabulum is not only a site in the pelvis with abundant bone reserves but also the optimal point to transmit upward force lines in the hip joint. In addition, soft tissue, such as the muscle surrounding the hip joint, is distributed around the true acetabulum [7-9].

A large number of clinical studies have revealed that reconstruction of the acetabulum at the true acetabulum level could achieve a sa-

Figure 1. A-C. Pre-operative anteroposterior and right hip oblique radiographs showing high hip dislocations with no previous operations. D-F. Transverse subtrochanteric femoral shortening osteotomy was performed for the right side and supported with autograft and cable-cerclage. G, H. Six month postoperatively the patient had excellent clinical (HHS score: from 39 to 92) and radiographic results with union and remodeling of both proximal femoral osteotomies.

tisfactory stability and a low long-term repair-rate [10], restore the normal anatomy of the acetabulum, and avoid the non-physiological wear of the prosthesis, thereby participating in extending the extremities and improving the abductor muscle. Therefore, a majority of investigators advocate prosthesis replacement in the location of the true acetabulum [11, 12]. Hence, during surgery, complete exposure of the periphery of the acetabulum lays the foundation, and the fossa and teardrop were considered as the markers in the gradual filing. Furthermore, upward migration of the acetabulum should be prevented, and attention should be focused on protecting the anterior and medial acetabular wall. Previous studies confirm-ed that if the center of the hip joint were moved upward for 1 cm, the intra-articular stress would increase by 5%, while if the center were lateral-posteriorly moved for 2 cm, the intra-articular stress would increase by 22%. This phenomenon indicated that the effect of superior migration of the hip joint center was less than that of the lateral migration of the hip joint center, where a moderate superior migration of the hip joint center could resolve the issue of covering the acetabular cup while exhibiting an insignificant impact on the stress of the hip joint [13]. Therefore, it is feasible to move the acetabulum upward moderately in cases with an insufficient bone mass on top of the acetabulum.

The reconstruction methods of acetabulum include moderate medial migration of the small acetabular cup and acetabular prosthesis, inferior migration of the small acetabular cup and acetabular prosthesis, as well as, structural grafting. Irrespective of the method used to reconstruct the acetabulum, the acetabular cup prosthesis is required to be covered by at least 70% of the host bone, to achieve the desired initial stabilization [14, 15].

In this study, the true acetabulum was reconstructed, and acetabulum was deepened by the medial shift in all patients, in order to locate the acetabular cup prosthesis in the center for bone coverage. All patients did not undergo structural bone grafting. The postoperative follow-up revealed an adequate location of the prosthesis, without loosening and sinking, and the hip function was improved significantly.

Reconstruction of the femur

In order to reconstruct the acetabulum in the true acetabulum, the highly dislocated femoral head needs to be pulled down. In patients with Crowe IV DDH, due to the long-term dislocation of the femoral head, the soft tissue surrounding the hip was severely contracted, the vascular nerve was shortened, and the strength of the abductor muscle was insufficient. Therefore, correcting the limb shortening while avoiding neurovascular injury is one of the major challenges in the treatment of patients using THA. Kiliçoğlu et al. [16] proposed that long limb extension after acetabulum reconstruction could be the major reason for sciatic nerve injury in hip replacement. It was speculated that the postoperative limb extension <4 cm is a safe limit in patients with Crowe IV DDH, while an extension of >4 cm may lead to sciatic nerve injury [17, 18]. In addition, an excessive release to achieve reduction of the hip joint will result in an unstable hip joint and cause postoperative dislocation. For patients with severe unilateral hip dysplasia or high dislocation, the ipsilateral lower limb appears to be shortened. However, its absolute length is often longer than that of the contralateral limb. Thus, if the reduction is achieved only by releasing the tissue surrounding the hip in patients with high dislocation, the limb will become extended after replacement and cause pain and abnormal gait in patients. Hence, most investigators agree that femoral shortening osteotomy should be routinely performed during replacement [19, 20]. Although a variety of programs are available for femoral shortening replacement, each has some advantages and disadvantages. The position for shortened osteotomy may be between the femoral trochanters or under the trochanters. The intertrochanteric osteotomy can increase the exposure of the acetabulum and femur, which facilitates an intraoperative release of soft tissue, inferior movement of the rotation center, as well as adjustment of the length of the lower limbs, and dilation of the abductor muscle. The disadvantage involves the dead points of the abductor and iliopsoas muscles, which leads to poor restoration of the postoperative abduction and hip flexion function. The advantage of subtrochanteric osteotomy is that the length of the resected bone can be adjusted flexibly according to the preoperative design and actual intraoperative situation. This feature is useful for adjusting the tension of soft tissue and length of lower limbs and retaining intertrochanteric metaphyseal bone intraoperatively without involving the dead points of abductor and iliopsoas muscles; thus, better abduction and hip flexion function can be achieved postoperatively. The drawback is a possibility of poor rotation alignment at the osteotomized site intraoperatively, burst fracture at distal and proximal ends of the resected bone, a risk of postoperative fracture non-union, as well as rotational instability. Concerning these risks, some investigators suggested fixation using the resected bone plate and strapping using steel wire. In the present study, the resected bone plate was reimplanted to increase bone mass and promote bony union at the osteotomized site. All the osteotomized surfaces achieved bone union post-surgery.

In summary, in the treatment of Crowe IV DDH adults with total hip replacement, the use of an acetabular cup and acetabular protrusion technique to reconstruct the acetabulum in the true acetabulum position combined with subtrochanteric osteotomy to restore the length of lower limbs can achieve satisfactory short-term results. However, the long-term curative effect remains to be elucidated.

Disclosure of conflict of interest

None.

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