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Experience with external fixation devices during preoperative preparation and planning of primary and revision hip arthroplasty in complicated cases of rigid hip deformity

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Objective To review external fixation used at preparation stage of primary and revision hip arthroplasty in complicated cases of rigid hip deformity to optimize patient outcomes. **Material and methods** Outcomes of 15 patients with considerable limb length discrepancy of lower limbs were reviewed. Shortening of 7 to 10 cm was observed in ten cases, and five had 5-to-7-cm discrepancy. All patients underwent two-staged surgical treatment including Ilizarov external fixation at the first stage followed by total hip replacement at the second phase. The external fixator was taken off at the end of distraction on the day of implant placement. The patients were followed up within 29 ± 17 months on average and maximum 57 months of two-staged surgical treatment. **Results** The Harris hip score measured 21 ± 9 prior to external fixation and 77 ± 13 after arthroplasty. The usage of external fixation allowed for limb length equalization in all the cases adapting soft tissues for the next arthroplasty surgery. No infection was reported. Four of fifteen patients developed dislocation of the prosthetic head (3 early and 1 delayed dislocations); two patients underwent closed reduction and another two had a revision arthroplasty to stabilize the joint. **Conclusion** External fixation devices used at preparation stage of primary and revision hip arthroplasty can be advocated for complicated rigid hip deformity to recover supportability of the leg, equalise limb length, adapt soft para-articular tissues, realign the centre of rotation and improve treatment outcomes.

Keywords: hip joint, total hip replacement, external fixation, Ilizarov method, limb lengthening, rigid deformity

INTRODUCTION

Total hip replacement (THR) is a major reconstructive surgery and surgeons have to monitor each case to determine the best course of treatment. The need for revision total hip arthroplasty continues to increase as the indications to total hip replacement broadens. According to S. Kurtz et al. [1], by 2030, the demand for revision hip replacement is estimated to grow in the U.S.A. by 137 %. The frequency of revision hip replacement is less in the Russian Federation as compared to overseas and is likely to grow over the next years [2].

Rigid deformities with the need of bringing the femur down make revision TRH and reduction of the head with the acetabular component difficult. Prevention of combined contractures of the hip joint and gradual adaptation of soft periarticular tissues are important for successful outcome.

The techniques that are used to transport the femur down include shortening osteotomy of the femur, transfer of the abductor origin and a portion of greater trochanter (Paavilainen method) skeletal traction or external fixation [3]. However, correcting osteotomies can result in nonunion, abductors' dysfunction, joint contracture and prevent early standard loading and active rehabilitation postsurgery [4]. Intraoperative limb lengthening can lead to stretching and injury to nerves and vessels with partial and complete paresis of major nerve trunks and thrombosis of major vessels [5, 6].

Several authors report the usage of monolateral external fixation device for gradual bone stretching and limb length equalisation prior to primary total hip arthroplasty in patients with developmental dislocation of the femur, chronic osteomyelitis of the femur and expressed dysplastic hip osteoarthritis [7–13]. Ilizarov external fixation was reported to be a safe and reliable method for periprosthetic femoral fracture with infection after cementless total hip arthroplasty in one clinical instance. [14]. Brinker MR et al. reported the results of Ilizarov

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gradual distraction to regain 6.7 cm of leg length in a severely contracted hip after a resection arthroplasty. Restoration of leg length allowed revision hip arthroplasty. The use of Ilizarov gradual distraction restored leg length and facilitated postoperative function [15].

The tactical choice of primary and revision total hip replacement to be used for complicated cases of limb shortening and dislocated femoral head or implant remains controversial. Half-pin external fixation device can be practical for femoral transport, limb length equalisation facilitating soft tissue condition. Pre-application of distractional external fixation as a preparatory stage to THR can be effective in complicated cases primary and revision THR. Our intention is to share the experience with two-stage procedure of THR performed for complicated cases.

Objective The purpose of the study was to review external fixation used at preparation stage of primary and revision hip arthroplasty in complicated cases of rigid hip deformity to improve patients' outcomes.

MATERIAL AND METHODS

Retrospective review was performed for 15 patients with considerable shortening of lower limbs who underwent primary and revision THR and prior external fixation between 2012 and 2017 in our centre. Informed consent for the use and disclosure of personal data was obtained from all patients.

Of 15 patients, there were 7 males and 8 females aged 55 ± 14 years. Patients were followed up for 29 ± 17 months of two-stage surgical treatment. Maximal period of observations was 57 months.

The Harris Hip Score was used for the assessment of the results of hip arthroplasty. A total score of < 70 is considered a poor result; 70–80 is considered fair, 80–90 is good, and 90–100 is an excellent result [16].

Statistical analysis was performed using Statistica version 6.1 with a two-tailed $p \leq 0.05$ for statistical significance. Data are presented as mean and standard deviations (M ± SD) for continuous variables. Correlation analysis was produced with gamma coefficient.

RESULTS

Ilizarov external fixation was applied for all patients of the study group prior to THR [17, 18]. Spinal anesthesia was used, and a pair of half-pins was bilaterally inserted in iliac wings out of 0.5 cm incision, with two wires placed in the femoral condyles. Distraction external fixation device was composed of two semi-arcs attached to half-pins and two semi-arcs mounted to the wires. Intraoperative distraction was provided, and aseptic dressings were applied to pin sites. External fixation device was removed during the next procedure of total hip replacement. Preparatory stage of treatment was aimed at less traumatic limb lengthening to avoid technical difficulties of extremity shortening during THR. Distraction lasted for 28 ± 21 days (range, 8 to 70 days) prior to joint replacement surgery.

Eleven of fifteen patients underwent previous surgeries on the operated joint. Seven patients had 1 to 2 procedures in the past, four had primary treatment and another four underwent 3 to 6 interventions prior to distraction external fixation. The majority of patients (n = 11) underwent THR prior to external fixation, among them 4 primary and 7 revision cases. Indications to THR included nonunions (n = 2), posttraumatic and dysplastic hip osteoarthritis grade III (n = 3), iliac-femoral neoarthrosis (n = 2), instability of an implant or spacer (n = 7, from them, 4 dislocations with the half being recurrent) and periprosthetic fracture (n = 1).

Considerable shortening of the involved limb was observed in all the cases measuring 7 to 10 cm in 10 and 5 to 7 cm in 5 out of 15 patients. Limb length was equalised in all the patients using distraction external fixation device. Gradual bone distraction facilitated adaptation of soft tissues, vessels and major nerve trunks for the next THR procedure and allowed for realigning rotation centre avoiding neurological complications at early and late postoperative periods.

Standard THR technique was employed for 10 out of 15 patients without femoral osteotomy. Transfemoral approach with extensive osteotomy of greater trochanter was used in 5 cases for optimal joint visualisation, acetabular component positioned anatomically, shortening remodeling Russian lock osteotomy and osteosynthesis of the fe-

mur with angular stable plate with performed for one patient. Ground allografts mixed with antibiotics were used for acetabular cavities in six cases. Allograft and metal mesh were applied to repair proximal femur defect in one case. Total hip arthroplasty was supported by Burch-Schneider reinforcement ring in one case. Bone allografts and acetabular augments were used to repair segmental acetabular defects in two patients. Total hip replacement was produced with cementless (n = 11), cemented (n = 3) and hybrid (n = 1) prosthesis.

Early postoperative period was uneventful in 10 cases. Five patients developed early postoperative complications. Two from five patients developed thrombosis of major veins of lower limbs that resulted in 2-year delay of revision THR (n = 1) and femoropopliteal bypass surgery (n = 1). One patient had dislocated prosthetic femoral head, tense hematoma bleeding from circumflex arteries and underwent embolisation of arterial branch circumflexing the femur, reduction of prosthetic femoral head and articular debridement. Two patients developed early dislocations. Four of fifteen patients had early (n = 3) and delayed (n = 1) postoperative dislocations. Two of the patients underwent closed reduction of dislocation and another two had subsequent revision arthroplasty to stabilise the joint.

Direct correlation was established between the number of previous interventions performed for the joint and frequency of dislocations following THR ($\gamma = 1$; $p = 0.01$). If there was more than one hip surgery reported in the history there was a greater probability of postoperative dislocation that was supposedly associated with extensive scars and abductors' dysfunction being likely progressive with each revision procedure. Postoperative dislocations could also resulted from acetabular or femoral defect size that required augment, reconstructive ring and mesh ($\gamma = 0.9$; $p = 0.007$).

Harris hip score showed good clinical and functional results obtained in 11 patients ($\chi^2_{Yates} = 4.80$; $p = 0.0285$), two fair and two poor outcomes following two-staged THR. The mean Harris hip score 21 ± 9 prior to external fixation and 77 ± 13 ($p = 0.0001$) following THR.

There is a clinical instance of a 60-year-old female patient (**Fig. 1**) who had surgery for DDH in 1965 when she was 9 years old. She underwent THR of the right joint in 2009 and THR of the left hip in 2010 for dysplastic hip osteoarthritis Kosinskaya grade III and Crowe type IV developmental hip dysplasia [19, 20]. Radiographs of the hip joint taken in 2014 showed loosening of the implant, migration of acetabular component and dislocated prosthesis. Dislocated and rotated pelvic component was located at the iliac wing level. Shortening of the right lower limb was 10 cm. Preoperative Harris hip score was 21.

Distraction external fixation of pelvis and femur was produced as the first stage of surgical intervention in April 2014. Spinal anesthesia was used, and a pair of half-pins was bilaterally inserted in iliac wings, with two wires placed in the right supracondylar femur. Distraction external fixation device was composed of two semi-arcs attached to half-pins and two semi-arcs mounted to the wires. Intraoperative distraction of 3 cm was provided. There was a 1 cm limb length discrepancy at 21-day external fixation. The second stage of treatment was produced after 21 days including revision cementless THR of the right hip, extensive osteotomy of greater trochanter, removal of hardware and broach debris and bone allografting. The femur was fixed with cerclage wire. The limb length discrepancy was completely eliminated. The patient showed improvement on discharge from the hospital. She could ambulate using crutches maintaining partial weight-bearing on the operated limb with increased range of motion in the joint. She reported no complaints and hip pains, demonstrated good functional outcome and complete ROM in the hip joint. The patient was happy with the outcome of surgical treatment. Radiographs of the hip joint showed stable hardware. The Harris hip score was 82 indicating to a good clinical and functional result. The usage of two-staged resulted in restored limb length and functional extremity exhibiting no vascular and neurological deficiency.

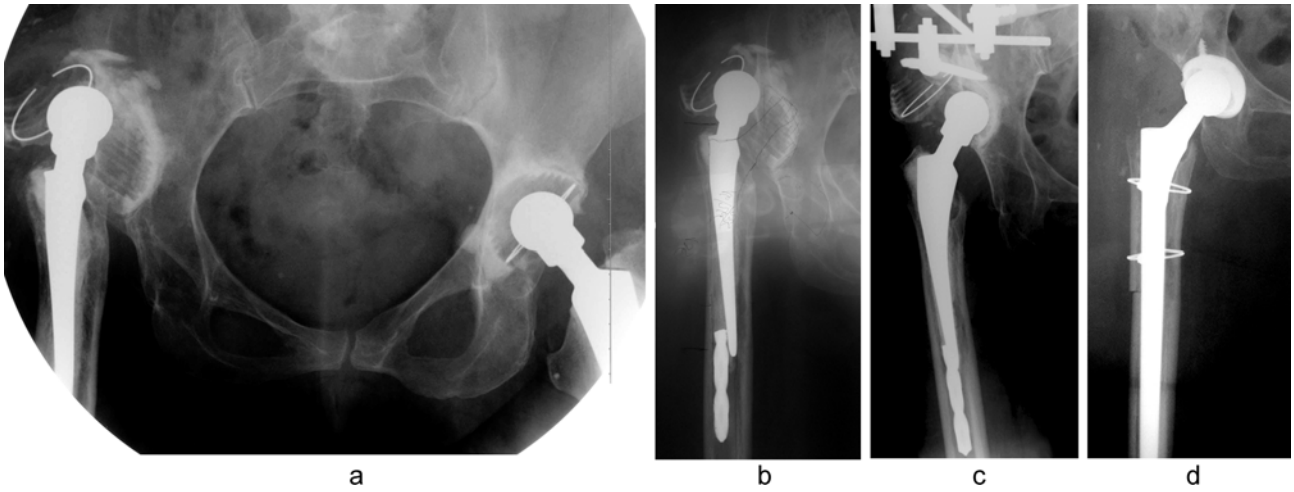

Fig. 1 Radiographs of pelvis of patient V. showing (a) preoperative view of two staged revision arthroplasty of the right hip; (b) preoperative view of two staged revision arthroplasty of the right hip; (c) distraction external fixation applied to the pelvis and femur; (d) revision arthroplasty performed for the right hip joint

DISCUSSION

The method of distraction external fixation applied prior to primary and revision THR in complicated cases could provide positive anatomical and functional results suggesting the effectiveness. Disadvantages with pre-distraction of lower limbs using external fixation may include prolonged inpatient stay and a risk of infection. A most common complication seen with external fixation devices is pin tract infection but timely antibiotic therapy is helpful in arresting the infection and it has no adverse effect on final outcome [21]. No pin tract infection was recorded in our series of two-staged THR. Some authors identify psychological difficulties with two-staged surgical treatment including prior femoral transport with external fixation device as compared with acute intraoperative manoeuvre [11]. A successful experience with intraoperative limb lengthening in THR with the extremity length regained and sciatic nerve function preserved is well documented [11, 22]. In our opinion, one-stage total hip arthroplasty is a high risk surgery in patients with rigid hip deformity and shortening of lower limb of more than 5 cm due to postoperative complications and prolonged rehabilitation period, so, two-stage surgical treatment should be considered. Despite the concern over prolonged inpatient stay and risk of infection the external fixation device applied in patients with rigid deformities allows for lower risk of postoperative dislocations, instability of prosthetic components and combined contractures. There have been positive experiences accumulated with external fixation used to restore limb length discrepancy prior to total hip arthroplasty without complications [7–15]. One-stage THR in the cases to result in satisfactory outcome can be technically demanding, whereas two-stage surgical intervention may succeed. Correlations established between the number of interventions recorded in medical history, the size of acetabular or femoral bone loss and frequency of dislocations observed after two-stage surgical treatment suggest that the extent of bone deficiency paraarticular muscles is important for long-term outcomes of total hip arthroplasty in patients with rigid deformity that is in line with other authors [2].

Positive long-term outcomes of THR are reported in 76 to 89 % of the cases [23]. Complication rate of two-stage THR with prior application of distraction external fixation device was not higher with our series as compared to internationally reported rates. A specific approach to preoperative planning is required for complicated cases of THR with evident topographic, anatomical changes, and rigid hip deformity and limb length discrepancy, in particular. A variety of tailored arthoplastic technologies can be considered for challenging cases including modalities for fixation of prosthetic components, possibilities with bone grafts and special constructs. Our findings indicate to the necessity of further exploration of the method offered to improve its effectiveness.

CONCLUSIONS

External fixation devices used at preparation stage of primary and revision hip arthroplasty can be advocated for complicated rigid hip deformity to recover supportability of the leg, equalise limb length, adapt soft para-articular tissues, realign the centre of rotation and improve treatment outcomes. We believe this approach is worth considering to be introduced into a wider practice.

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