

Ilizarov hip reconstruction without external fixation: a new technique

A. H. Krieg · U. Lenze · C. C. Hasler

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Abstract

Purpose The Ilizarov hip reconstruction is a well accepted but complication-prone operative salvage procedure in chronically dislocated hips, not least due to the long-term application of external fixation. Although the advantages of fully implantable devices are well known in limb lengthening and are described consistently, until now, external fixation has been used exclusively to perform the Ilizarov hip reconstruction procedure. We present a new technique of Ilizarov hip reconstruction with purely internal implants.
Methods A 14-year-old girl with a history of spina bifida presented with a 4-cm-short right leg, a Trendelenburg gait and a complex neurological disease expression. Because of refusal of external fixation by the patient and significantly lower complication rates, an Ilizarov hip reconstruction without external fixation was performed. A locking compression plate was applied to fix the proximal femoral valgus-extension osteotomy and a motorised intramedullary distraction nail was used for the distal, lengthening-variation osteotomy.

Results A healing index of 33 days/cm and full weight bearing after 6 months were noted. At the 1 year follow-up, the patient showed an improvement of the Trendelenburg gait, as well as successful leg equalisation. Satisfaction to a high degree was additionally noted by factors such as reduced pain, the ability to wear workaday clothes and cosmetically appealing scars. No complications were recorded.

Conclusion The exclusive use of internal implants for Ilizarov hip reconstruction is a feasible and patient-friendly alternative to traditional methods. Their use, however, may be restricted by geometric preconditions.

Keywords Hip dislocation · Surgery · Limb lengthening · Ilizarov technique · Osteotomy · Methods · Gait

Introduction

Pelvic support osteotomies have a long tradition in orthopaedic surgery and trace back to the first half of the 20th century. They have been described in numerous variations and by several authors [1–4] for stabilisation of the hip by medial shifting of the anatomical axis compared to the mechanical axis of the femur [1]. These angulation osteotomies caused an excessive valgus of the mechanical axis alignment and disregarded the coexistent leg length discrepancy. Gavril Ilizarov was the first to combine a proximal valgisation osteotomy with a second, more distally located, lengthening-variation osteotomy to restore physiological force distribution at the knee and ankle joint and to equalise leg lengths [5, 6]. Furthermore, he exposed the importance of an additional extension momentum at the proximal osteotomy for improved stability of the hip [5, 6]. According to the Ilizarov method, the use of external fixation was an inherent part of this procedure, which was named “Ilizarov hip reconstruction” [5–7].

Within the last decade, fewer complications and greater comfort have led to an incremental replacement of external fixators by intramedullary nails for limb lengthening as well as deformity corrections and rendered these systems a valuable alternative to traditional external fixation [8–10]. Nevertheless, until now, external fixators have been used to

A. H. Krieg (✉) · U. Lenze · C. C. Hasler
Paediatric Orthopaedic Department, University Children's Hospital (UKBB), P. O. Box, Roemergasse 8, 4005 Basel, Switzerland
e-mail: andreas.krieg@ukbb.ch

perform the Ilizarov hip reconstruction due to functional application and the lack of reliable experiences with internal systems. Therefore, hinged external fixators with huge pins were applied, which not rarely had an unsettling effect and, thus, often led to reduced compliance. Not least due to muscular transfixation, they were additionally associated with a high rate of considerable complications, patient discomfort and cosmetic discontent, as well as elongated hospitalisation and rehabilitation.

We present a new technique of the Ilizarov hip reconstruction with internal systems exclusively. A locking compression plate is applied to fix the proximal valgus-extension osteotomy and a motorised intramedullary distraction nail (Fitbone®) is used for the distal, lengthening-variation osteotomy.

Case

A 14-year-old girl with a history of spina bifida presented with a fixed, irreducible neurogenic hip dislocation and a 4-cm shortening of the right leg. The femoral head was situated within a false acetabulum and a capsule of connective tissue above the original acetabulum (Fig. 1a–c). The myelomeningocele at the L4/L5 level, which was closed directly after her birth in 1994, was accompanied by a complex disease pattern. From an orthopaedic point of view, there were osseous abnormalities of some vertebral bodies and ribs, agenesis of the sacral bone and an operated clubfoot on the left side. The patient did not suffer from pain and was able to walk but sought orthopaedic advice mainly by reason of a stigmatising Trendelenburg gait, as well as considerable leg shortening (4 cm), which was equalised by a cosmetically unaccepted shoe lift. Passive range of motion of the right hip was flexion/extension 100°-0°-0°, abduction/adduction 15°-0°-25° and external rotation/internal rotation 65°-0°-20°. Furthermore, a flexion contracture of both knees (right 5°, left 10°) and an

equinus of the left foot (15°) were found (Fig. 2a–d). The preoperative gait analysis revealed activity in the flexors of the right hip joint only with coincidental activity of the extensors of the left hip joint. The shortening of the right leg was compensated by flexion in the left hip and knee and, thereby, led to a reduced functional stability of the left leg. As the electromyogram did not show electric muscle potentials of the right gastrocnemius and right anterior tibial muscle, the right leg was found to serve as a stilt during the process of walking. Therefore, an Ilizarov hip reconstruction was planned, as it was deemed the only reasonable treatment option for gait improvement, limb length equalisation and functional stabilisation of the left leg. Since the patient was 14 years old with closed growth plates at the affected leg before surgery, no significant progressive leg length discrepancy due to remaining growth potential was expected.

Because of refusal of external fixators by the patient, significantly lower complication rates and long-standing experiences with the advantageous Fitbone® system [10, 11], external fixation was waived and internal systems were used exclusively, for the first time ever.

Before surgery, anteroposterior and lateral long-standing radiographs (LSR) of both legs, as well as the hip in maximal adduction (cross-legged adduction) and abduction, were taken (Fig. 3a–b) and a meticulous preoperative planning (Fig. 4a–b) was performed according to Paley's and Baumgart's recommendations [12, 13]. At first, radiographs with the hip in maximal abduction serve as an indicator for any adduction contracture which has to be considered (Fig. 3a), since it would constrain abduction postoperatively. Furthermore, the amount of valgus correction is determined based on the so-called drop angle, which is representative for the patient's ability to actively stabilise the pelvis. It is objectified on a single-leg stance radiograph by measuring the angle between the horizontal line of the pelvis and the femoral shaft (drop angle). To provide a stable single-leg stance, overcorrection is



Fig. 1 A fixed, irreducible neurogenic hip dislocation of the right leg with adduction contracture in a conventional supine radiograph (a) and a three-dimensional reconstruction of computed tomography (CT) data (b, c)



Fig. 2 Photographs of the clinical appearance at first presentation. There was a leg length discrepancy of 4 cm (a, b), a flexion contracture of both knees (c, d) and an equinus of the left foot (a–d)



Fig. 3 Preoperative radiographs. The hip in maximal abduction served as an indicator for any adduction contracture (a). The amount of required valgus is partly determined by the cross-legged adduction angle, which measures 25° in our case (b)

recommended (valgus corrective angle = drop angle + 15°–20°) [12], (Fig. 3b).

Adduction leads to external rotation. Subsequently, the distal fragment needs to be internally rotated at the proximal osteotomy (20°). We have the experience that the amount of necessary rotation is not fully predictable. In our case, some residual external rotation needs to be addressed in future. By reasons of an anticipated slight remodelling at the proximal osteotomy site, a mild overcorrection by 15° was planned, resulting in a desired valgus angle of 40°.

Additionally, an accessory geometrical shortening of the affected leg, as an effect of the proximal valgisation, must be included in preoperative deliberations. In our case, a total final leg length discrepancy of 5.5 cm was anticipated considering both a geometrical shortening by means of the proximal valgisation osteotomy as well as mild lengthening due to distal varisation. For planning purposes, the LSR

was graphically combined with the radiograph of the adducted hip, allowing a full-scale simulation of the planned procedure.

First, we performed the distal lengthening–varisation osteotomy and inserted a straight Fitbone® TAA 1160 exactly as planned (Fig. 5b, c). This proceeding was required due to anatomically restricted interlocking options at the intersection point between the inserted nail and the provided plate, which could be more easily overcome by adjusting a proper plate position. Thus, in a second step, the pelvic support osteotomy was performed and an industrially pre-bent locking compression plate (LCP) was placed laterally (Fig. 5). Corrections of the mechanical axis alignment were intraoperatively determined with the help of a grid plate with radio-opaque straight lines, which was placed underneath the patient on a radiolucent table. Thereby, the anatomical correlation between the centres of

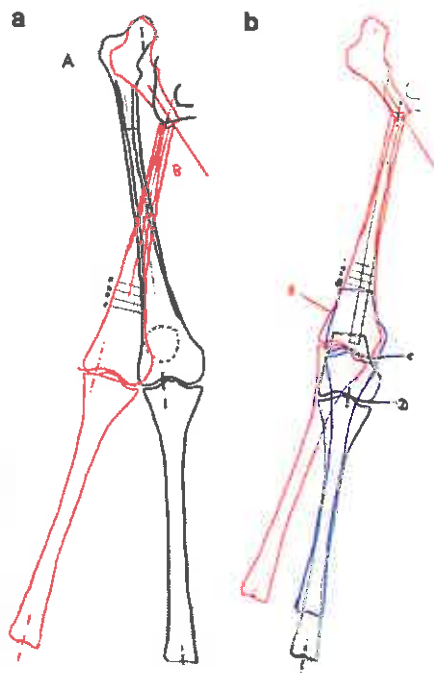


Fig. 4 Preoperative planning. First, we planned the valgus osteotomy (a) with a 40° valgus angle according to situation B. In a second step, the lengthening–varus osteotomy was planned (b) by determining a proper varus angle (in our case, the largest varus angle possible) and the appropriate osteotomy level in order to achieve the desired axis alignment. Situation C (blue) represents the required relationships of the bone segments after intraoperative correction. The green drawing (situation D) depicts the final result after completion of the lengthening procedure

the hip, knee and ankle joint can be assessed. In this special case, we used the projected centre of the ischium to calculate the proximal centre of the mechanical axis on this site. Projection of the ipsilateral hip is only feasible in an otherwise symmetric normal pelvis.

Because of the stable fixation, a cast was abdicated and early motion was allowed. Thus, after a bed rest of 72 h, the patient was put on partial weight bearing (max. 25 kg) and had physiotherapy for the hip, knee and ankle joint. Distraction was started 5 days postoperatively and a distraction rate of 1 mm per day was scheduled.

The patient was periodically examined with radiological follow-ups at least bi-weekly during distraction and four-weekly during consolidation (Fig. 6). A distraction index of 1.07 mm per day as well as a healing index of 33 days/cm and full weight bearing after 6 months were recorded. At the 1 year control, the passive range of motion of the right hip constituted the following extent: flexion/extension 100° – 0° – 10° , abduction/adduction 35° – 0° – 30° and external rotation/internal rotation 45° – 0° – 25° . The Trendelenburg gait appeared to be clearly improved, whereas single-leg stance, however, was still not properly possible in

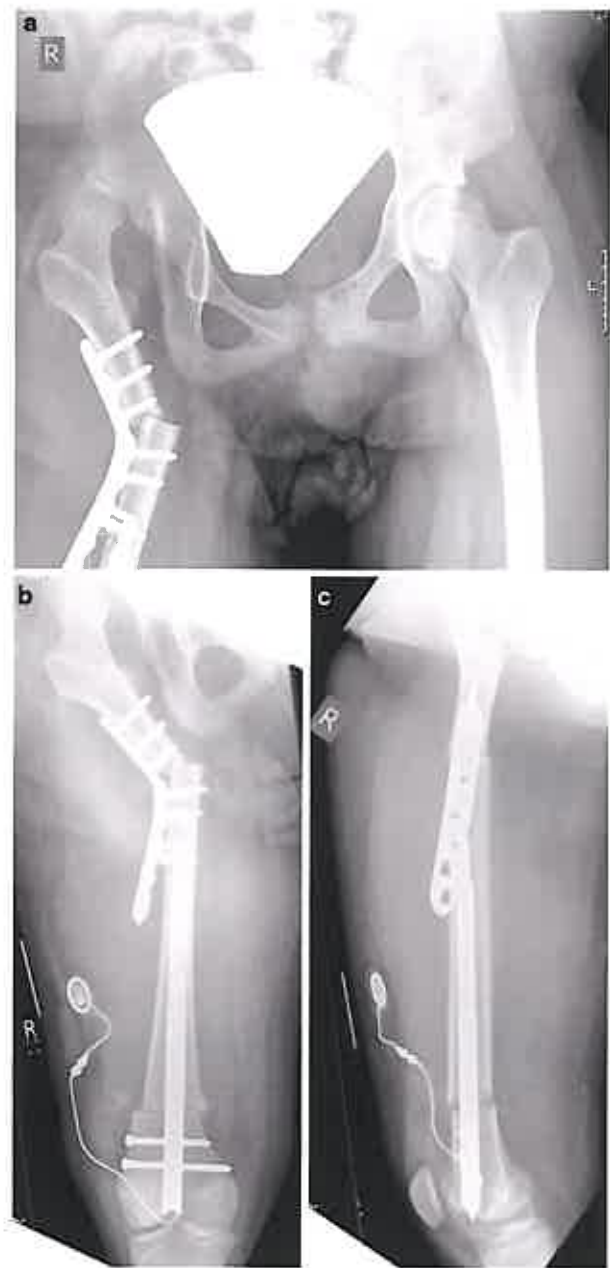


Fig. 5 Postoperative radiographic assessment of the hip and the right femur. At the proximal valgus-osteotomy, the distal part of the femur was displaced one half-shaft thickness medially and osteosynthesised by a locking compression plate (LCP) (a). An extension–correction was performed at the same level to counter any fixed flexion deformity (c). For lengthening and varusation purposes, a second osteotomy was performed more distally and a Fitbone[®] TAA was inserted (b, c)

consequence of neurogenic muscle insufficiency. Additionally, the flexion contractures of both knees did not persist, whereas the equinus of the left foot (15°) was still found (Fig. 7). The LSR of both legs showed equalised

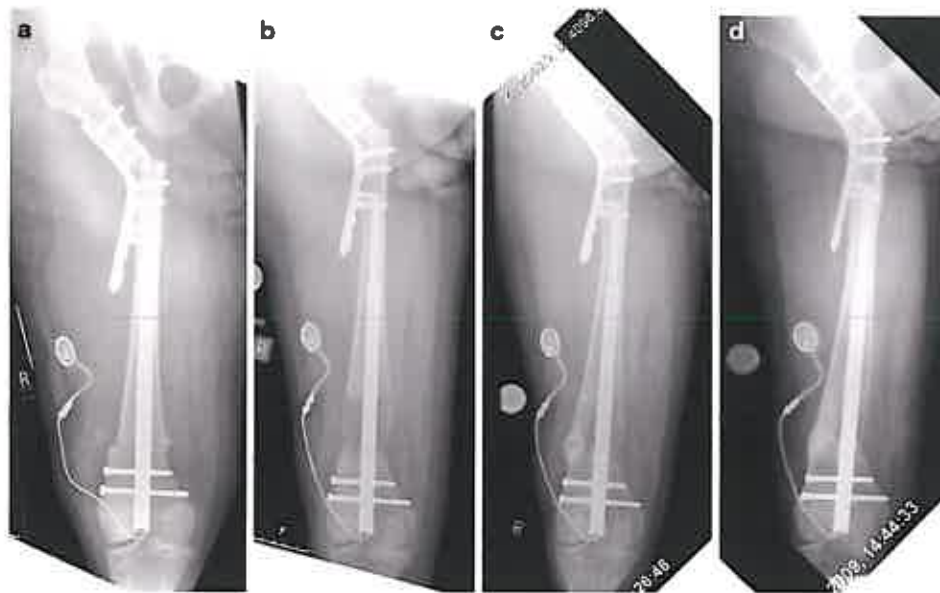


Fig. 6 Radiographs 2 days (a), 3 months (b), 6 months (c) and 11 months (d) postoperatively. Complete remodelling of the proximal osteotomy site is visible (c, d), as well as advancing consolidation of the distraction callus after lengthening of 5.5 cm (b, c, d)



Fig. 7 Photographs of the clinical appearance 12 months postoperatively. There is still a moderate raised stand of the left pelvis (a, b) due to a persisting equinus of the left foot (a–d)

limb lengths and a correct axis alignment after 40° pelvic support osteotomy (Fig. 8).

Discussion

The Ilizarov hip reconstruction is a well accepted operative salvage procedure in chronically dislocated hips of adolescents for providing stability, gait improvement and leg

length equalisation. As it also considers the realignment of the knee joint and permits equalisation of the concomitant leg length discrepancy, usually, external systems have been required up to now.

Especially in limb lengthening, the advantages of fully implantable techniques such as low complication rates and fast rehabilitation are well known and described consistently in the recent literature [10, 14]. Beside these issues, particularly soft factors such as improved comfort and



Fig. 8 Bipedal long-standing radiograph 12 months postoperatively with a valgus angle of 40° and moderate obliquity of the pelvis. Both the proximal osteotomy site and the distraction gap show consolidation

cosmetics play an increasingly important role and represent additional criteria for the appraisal of surgical techniques. By now, the Ilizarov procedure was said to be a complication-prone method, not least due to the long-term application of external fixators. Likewise, some authors report on high complication rates with the index procedure, whereas complications were mainly associated to external fixation [15, 16]. In our case, with the exclusive use of internal systems, no complications were seen and a solid bony formation was obtained. Apart from the advantageous intramedullary leg lengthening, this is partly attributed to the LCP at the proximal osteotomy site, providing an angle-fixed healing and remodelling of the valgus osteotomy (Fig. 5a–d). In a similar manner, Hogan et al. used

two dynamic compression plates (DCP) to fix a modified Hass subtrochanteric valgus osteotomy and allowed early motion and physiotherapy [17]. In our case, the accelerated rehabilitation and fast bone healing is clarified by a healing index of 33 days/cm and full weight bearing after 6 months. In contrast, El-Mowafi reports on 25 patients (mean gain of length 5 cm) who underwent the Ilizarov hip reconstruction procedure and spent a mean duration of 7 months in the Ilizarov frame [18]. This may result in a reduced compliance, especially in the case of repeated treatment with external fixators due to remaining growth potential or preceding lengthenings.

As is known, intraoperatively, the Fitbone[®] nail allows certain corrections in a three-dimensional manner, whereas corrections of the axis alignment or implant position cannot be implemented postoperatively [10]. This plays an important role, especially in determining the osteotomy sites, preoperatively. The more distal the proximal osteotomy is performed, the more medial the resulting pivot point of the femur and, thus, the higher the amount of varisation required at the distal osteotomy. However, the amount of varus correction is limited by geometrical preconditions of the femur. Further restrictions derive from a mandatory osteotomy level 7–11 cm from the joint line to assure stable nail interlocking, which may result in any translation. The accomplishable amount of varus correction is detected by the preoperative planning, which gives information about the required osteotomy level and the amount of correction in respect to individual anatomical preconditions.

Corrections of the axis alignment or implant position cannot be changed postoperatively. Consequently, meticulous preoperative planning is of outmost importance and needs to be accurately implemented during surgery. However, corrections are only possible if the intramedullary cavity is reamed with rigid and straight reamers (not flexible ones). Only by using rigid reamers, which do not follow the line of minor resistance, can the requirements of the preoperative planning be accomplished by means of an intramedullary nail.

In contrast, external fixation is more forgiving by offering postoperative adjustment options and, hence, does not require such a high degree of precision. Furthermore, the conventional accomplishment of the Ilizarov hip reconstruction allows a larger amount of correction, especially at the distal site, and is less time consuming during surgery.

The Ilizarov hip reconstruction stands out from other salvage procedures mainly by the improved functional outcome. Total hip arthroplasty, in contrast, which is demanded by some authors [19, 20], is—predominately in children and adolescents—afflicted with a high risk of complications [21, 22] and does not counteract the

insufficiency of the glutei muscles in a proper fashion. According to Inan et al. [23], who examined the influence of pelvic support osteotomies in congenital dislocated hips on the gluteus medius muscle, the mentioned procedure even restores abductor muscle length and volume [23]. Hence, it is our opinion that the indication for total hip arthroplasty in chronically dislocated hips should be preserved for adulthood if positive effects of the pelvic support osteotomy subside and symptoms reoccur. Since paralysis of important muscles around the hip may increase the risk of prosthesis instability, total hip arthroplasty would not be a valuable future alternative in our case.

However, novel prosthesis designs with modular stems are available, offering advanced options for anatomical reconstruction, even in complex situations [24].

The follow-up time in our case was 12 months and, thus, no reliable statements about any long-term effects can be made. However, since there are no long-term results, studies are requested, in general, to substantiate the protective effects of the Ilizarov hip reconstruction with evidence [25].

In the reported case, gait improvement, leg lengthening as well as constitution of a proper mechanical axis alignment were performed successfully (Fig. 7). An improvement of the gait with reduced limping was mainly achieved by the pelvic support osteotomy, which deters the pelvis to drop, and the limb length equalisation. Since internal systems without the need for transmuscular fixation were used exclusively, fast rehabilitation was achieved and no complication, particularly no infection, was seen. Additionally, factors such as reduced pain, the ability to wear workaday clothes and cosmetically satisfying scars play an important role (Fig. 9). Despite all the advantages of internal systems,



Fig. 9 Outward appearance of the right leg with cosmetically satisfying scars at the thigh (a) and knee (b)

geometric preconditions such as the size of the medullary canal and axis deviations may limit especially the application of the intramedullary lengthening nail and put higher demands on preoperative planning, precise operative technique as well as the skills of the surgeon compared to external fixation. Nevertheless, even complex situations with a large amount of required varus correction can be accomplished by means of intramedullary systems, but may necessitate an additional correction osteotomy after consolidation to restore the physiological distribution of mechanical forces. In such a case, this circumstance combined with the advantages of intramedullary nailing have to be weighed against a single-phase procedure with external fixators, which has considerably higher complication rates, as well as pain, cosmetic discontent and longer times for healing and rehabilitation.

However, the exclusive use of internal systems for Ilizarov hip reconstruction is a feasible and patient-friendly alternative to traditional methods which should necessarily continue to be performed.

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