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EDITORIAL

Total hip arthroplasty for sequelae of childhood hip disorders: Current review of management to achieve hip centre restoration

Anil Thomas Oommen

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Abstract

Adults requiring total hip arthroplasty (THA) for childhood disorder sequelae present with shortening, limp, pain, and altered gait. THA, which can be particularly challenging due to altered anatomy, requires careful planning, assessment, and computed tomography evaluation. Preoperative templating is essential to establish the appropriate acetabular and femoral size. Information regarding neck length and offset is needed to ensure the proper options are available at THA. Hip centre restoration must be planned preoperatively and achieved intraoperatively with appropriate exposure, identification, and stable fixation with optimum-size components. Identifying the actual acetabular floor is essential as changes include altered anatomy, distortion of the margins and version changes. Proximal femur changes include anatomical variation, decreased canal diameter, cortical thickness, changes in anteversion, and metaphyseal and diaphyseal mismatch. Preoperative assessment should consist of limb assessment for variations due to prior surgical procedures. Evaluation of the shortening pattern with the relationship of the lesser trochanter to the teardrop would help identify and plan for subtrochanteric shortening osteotomy, especially in high-riding hips. The surgical approach must ensure adequate exposure and soft tissue release to achieve restoration of the anatomical hip centre. The femoral components may require modularity to enable restoration of anteversion and optimum fixation.

Key Words: Total hip arthroplasty; Childhood disorder sequelae; Templating; Hip centre restoration; Soft tissue release; Offset

Core Tip: Total hip arthroplasty for childhood disorders in adulthood requires careful planning and awareness regarding the acetabular and femoral anatomic variations. Preoperative planning must include templating to understand acetabular and femoral sizing, offset, and neck length requirements, while modularity may be needed to address any meta-diaphyseal changes. Small acetabular and femoral components are commonly required in these hips to achieve good fixation. Preoperative assessment of the shortening pattern would help plan for a femoral shortening osteotomy, which may be necessary in patients with high-riding hips. Adequate exposure, extensive soft-tissue release, and restoration of the hip centre, leg length and offset are required to achieve favourable long-term outcomes.

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INTRODUCTION

Total hip arthroplasty (THA) for sequelae of childhood disorders could be challenging, with distortion of normal anatomy, poor development, and limb length discrepancy[1-3]. The presentation at THA is associated with shortening, pain, and functional limitations. Planning, templating, intraoperative soft tissue releases, identification of true acetabulum, and hip centre restoration would achieve normal anatomy and limb length correction[1]. Available data has literature regarding individual conditions[1,2,4-6]. Bony and soft tissue anatomical changes must be assessed, especially for hips with prior surgical procedures. This editorial addresses the possible anatomical variations, planning and management principles for THA in these difficult situations.

PREOPERATIVE PLANNING

A clinical hip examination with detailed neuromuscular assessment is required before performing THA. Radiological examination with proper anteroposterior (AP) and lateral views, including the entire femur and the limb, would be essential to identify the presence of proximal femoral anatomic variations (*e.g.*, femoral bowing) and to quantify the degree of limb length discrepancy. Computed tomography (CT) can be used as an adjunct to assess bony abnormalities and acetabular and femoral version.

Preoperative examination and assessment need to be meticulous as there is often a history of several prior surgeries, multiple incisions, and significant soft tissue/skin scarring (Figure 1).

PREOPERATIVE TEMPLATING

Templating provides essential information regarding the possible component sizes for the acetabulum and the femur. The horizontal offset and limb length discrepancy must be assessed to plan for various offset and neck length options for the proposed THA (Figures 2 and 3)[7,8]. Preoperative templating could be done using the magnification adjustments on any computer with digital X-ray viewing software[8]. Preoperative templating must be corroborated with intraoperative findings as most centres lack the availability of navigation or robotic technology.

THA CONSIDERATIONS IN CHILDHOOD DISORDERS

Soft-tissue and bony anatomy

Childhood disorders lead to improper development of the acetabular cavity, hemipelvis, and femoral canal[3,6]. Acetabular changes include small hypoplastic and ill-defined shallow cavities with thin anterior and posterior walls and possibly deficient AP and/or posteroinferior columns; the ilium itself is often also poorly developed. The acetabulum must be carefully templated and planned as the cup size may be small in diameter. Intraoperatively, the true acetabulum must be identified, which is done by placing a retractor in the obturator foramen. Intraoperative imaging is a powerful adjunct to confirm positioning before beginning to ream[1,3,6,9,10]. Reaming and preparation must be done judiciously after identifying the true acetabulum and assessing the anterosuperior and posteroinferior columns. The acetabular component needs careful sizing for the best fit, small component, and maximum preservation of bone stock. The acetabular shell should be secured with screws for immediate mechanical stability of the construct.

The femoral anatomical variations are changes in the femoral head, abnormalities in the neck, femoral anteversion (Figure 4), and metaphyseal changes with a meta-diaphyseal mismatch. The canal itself could be narrow with variable degrees of anterior and lateral bowing[6,9]. Prior childhood femoral lengthening procedures could pose challenges with

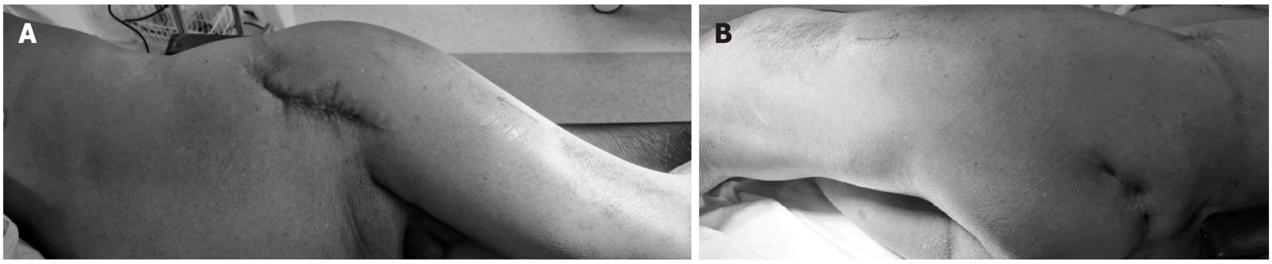

Figure 1 Skin scarring is not uncommon at total hip arthroplasty for childhood disorder sequelae. Patient in lateral position. A: Anterior aspect surgical puckered scar extending from the anterior superior iliac spine suggestive of scarring of the anterior soft tissues; B: Posterior scar with puckering posterior to the greater trochanter.

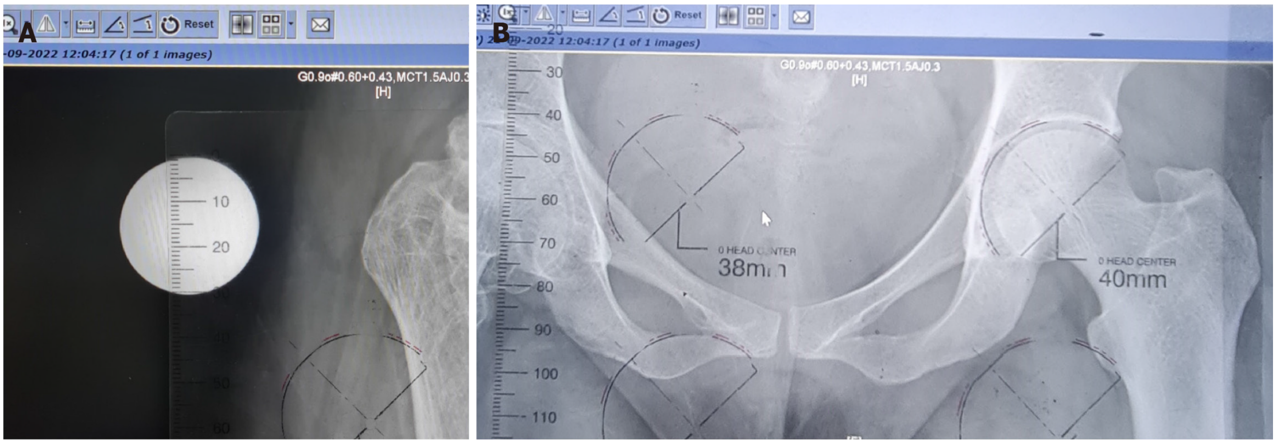

Figure 2 Templating with digital X-rays using a computer. A: 3-cm diameter metal ball is strapped to the thigh for X-ray. The scale on the template is matched to 3 cm by using the zooming feature (zoom in or zoom out); B: Match the size of the acetabulum to the correct size. Care is taken to assess the optimal size with respect to the teardrop, lateral edge, and acetabular floor. Arrows indicating the ball size matched and the template matching acetabular component size.

femoral canal preparation, and reaming must be done with care for optimal size assessment (Figure 5).

The main components of the standard soft-tissue hip envelope are the iliofemoral ligament, which limits external rotation and extension; pubofemoral ligament, which limits abduction and external rotation; ischiofemoral ligament, restricting flexion, adduction and internal rotation; and the annular ligaments, contributes to stability in hip flexion and extension[7].

Planning for soft-tissue and capsular releases should be based on a thorough preoperative physical examination and radiographic assessment. Identifying and understanding the type of preoperative hip shortening is also critical in determining the probability of requiring a subtrochanteric shortening osteotomy. Shortening could be supratrochanteric, with the femoral head centre below the level of the greater trochanter and the lesser trochanter at the level of the inferior aspect of the teardrop (Figure 6)[7]. Shortening is described as infratrochanteric, with the relationship between the greater trochanter and the femoral head centre maintained while the lesser trochanter is above the level of the teardrop (Figure 7). Combined supratrochanteric and infratrochanteric shortening may also exist (Figure 8). Supratrochanteric shortening would require a low neck cut and concomitant soft-tissue releases with a short-neck stem with a low amount of femoral offset. A subtrochanteric shortening osteotomy is more commonly needed for infratrochanteric shortening and in cases with combined shortening[7].

The proximal migration of the femur would require extensive soft tissue and capsular release on the acetabular and femoral aspects to achieve restoration of the horizontal offset. Stable reduction with the restoration of the hip centre of rotation (COR) is usually achieved with a 360 release of the soft tissue and capsule, sparing the abductors. Subtrochanteric shortening osteotomy would be required in high hips to achieve reduction and COR restoration. Soft-tissue balancing with COR restoration is essential to restore normal hip biomechanics[7].

Stability and optimal fixation of the osteotomy are ideally achieved with a modular stem. Modularity in the femoral component would be suitable for version adjustment, addressing the meta diaphyseal mismatch, and obtaining good proximal and distal fixation[9]. This will ensure optimal load distribution over the proximal and distal femur and prevent stress shielding.

Preparation and reaming of the femur must be done sequentially with caution as there is a high risk for calcar fractures or distal fractures due to osteoporosis, anatomic deformities and small calibre femoral canals. Fractures encountered intraoperatively require additional stabilisation with wiring or plate osteosynthesis and are progressed slowly with limited weight bearing (Figure 9).

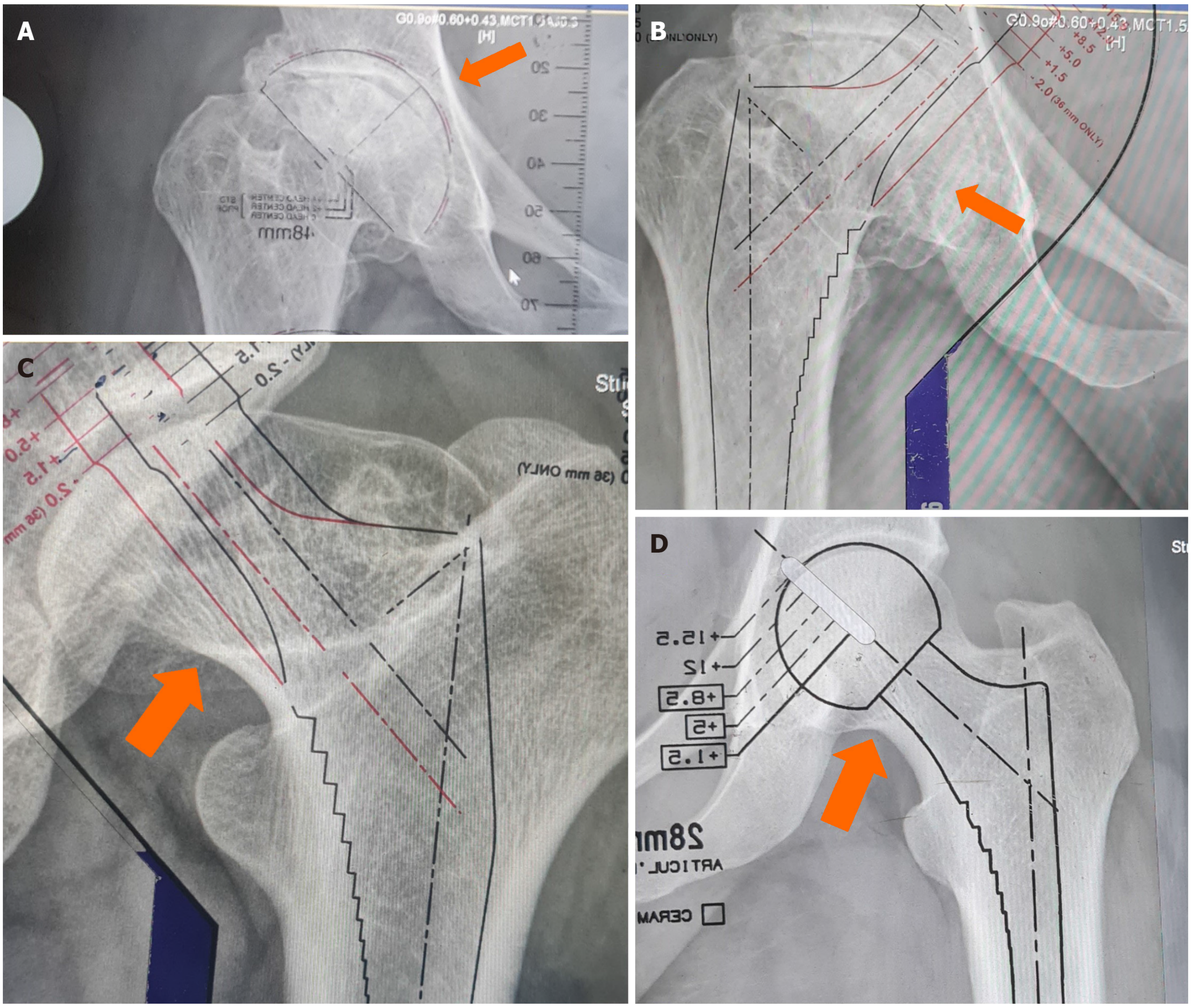

Figure 3 Routine preoperative templating is done for all cases for total hip arthroplasty in our unit using the described method. A: Affected side size shows larger size to due to distortion – indicated by the arrow. Restoration of hip centre was done with the same size; B–D: Templating the femur shows low neck cut, normal offset available is oversized in 3 hips as indicated by the arrows. Soft tissue release combined with use of a shorter offset/neck would be required tore produce offset on the normal side which is checked intraoperatively. Primary hip implants are available with short, normal and high offset options.

Anatomical COR restoration is ideal to restore limb length, horizontal offset, and correct limb length discrepancy. The shortening and altered gait pattern with back pain are the common complaints on presentation in adulthood at THA.

Femoral shortening with modular stem fixation would necessitate protected weight bearing till complete union of the osteotomy.

The gait pattern would take a few months to stabilise, and these individuals are satisfied with restoring limb length and hip stability.

THA in childhood disorders ideally requires anatomical hip centre restoration to reproduce biomechanics, limb length, offset and increased survivorship. The risk of dislocation or instability in these hips would be low, particularly with anatomical hip centre restoration. High hip centre with lateralisation could lead to early symptomatic loosening requiring revision. Although hip centre elevation up to 1 cm has shown good long-term survivorship, it would be ideal to attempt native anatomic hip centre restoration in these hips[11,12].

SPECIFIC PATHO-ANATOMIES

Dysplastic hip

Sequelae of developmental dysplasia of the hip (DDH) are among the most common childhood disorders requiring THA in adulthood. The initial retroversion of the femur neck during early development gradually leads to varying degrees of excessive anteversion in these hips. Coxa valga with narrowing of the medullary canal at the isthmus and reduction of the external medullary diameter are typical of the dysplastic hip[6]. The medullary flare is lost with poor femur development, a narrow medullary canal, and decreased canal size. Awareness regarding the mismatch of the diaphysis and metaphysis

Table 1 Crowe classification hip dysplasia

Crowe type	Description
Type 1	< 50% of the vertical diameter of the femoral head; < 10% of the height of the pelvis
Type 2	50%–75% of the vertical diameter of the femoral head; 10%–15% of the height of the pelvis
Type 3	75%–100% of the vertical diameter of the femoral head; 15%–20% of the height of the pelvis
Type 4	> 100% of the vertical diameter of the femoral head; 20% of the height of the pelvis

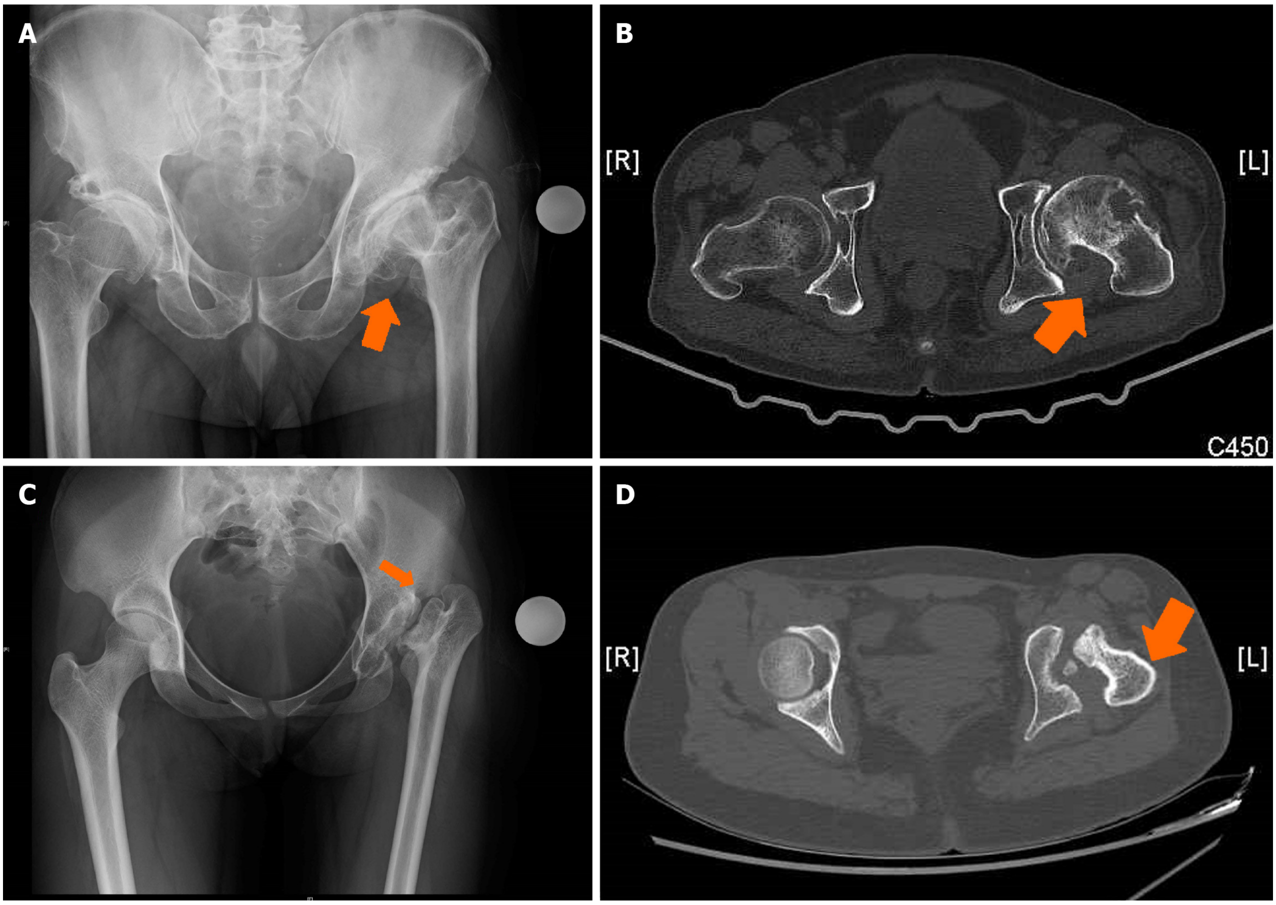

Figure 4 Anatomical abnormalities in the proximal femur include anteversion changes. A and B: X-ray of both hips anteroposterior (AP) showing dysplastic hip left with computed tomography (CT) assessment showing increased anteversion and deformed head and acetabulum; C and D: X-ray of both hips AP showing postseptic sequelae in left hip at total hip arthroplasty with computed tomography (CT) images showing large medial osteophyte, head malformation and increased femoral anteversion. Arrows indicating the changes in the X-ray and CT images. Preoperative evaluation helps in identification and adjustment of intraoperative femoral version.

is essential and would necessitate using modular stems for optimal stability, fit, and long-term survivorship[9]. The Crowe classification would help preoperative planning for soft tissue release and implant option requirements for THA [10,13,14] (Table 1).

Acetabular changes vary from malposition due to superolateral translation, version, size variation and incongruity[6]. The distortion could occur in both AP and transverse planes, with the changes well seen in preoperative CT evaluation.

The high hip centre has been advocated for Crowe 2 or 3 hips; however, restoration of the anatomical hip centre would be preferred for restoration of normal biomechanics and good long-term outcome (Figure 10)[11,12].

Soft tissue contractures would be significant, especially with high-riding hips and considerable shortening. Careful soft tissue balancing combined with subtrochanteric shortening to restore the hip centre would reduce the risk of neurological injury in these high hips with combined supra and infra trochanteric shortening (Figure 11)[6,7].

THA IN PERTHES DISEASE, SLIPPED CAPITAL FEMORAL EPIPHYSIS

Perthes disease is characterised by femoral head distortion, gradual deformation, and collapse with limb shortening.

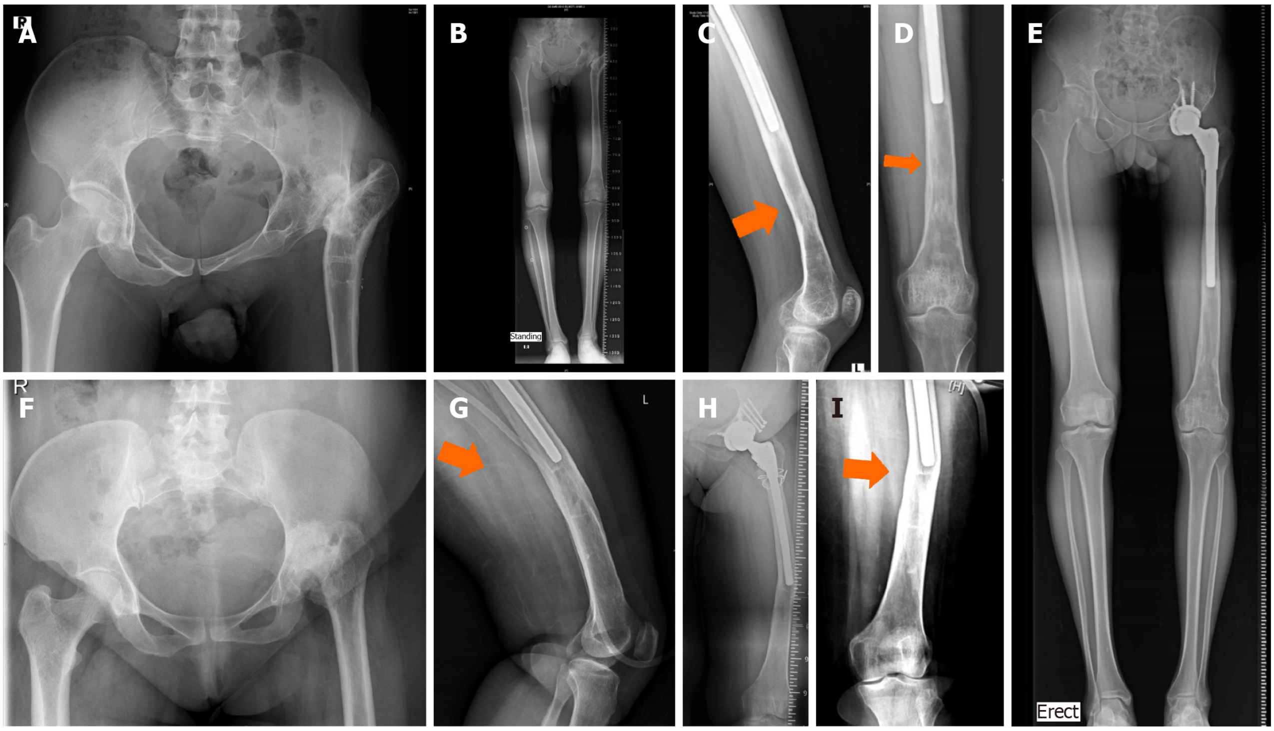

Figure 5 Prior femoral procedures produce distortion in the proximal and/or distal femur. A–E: Prior proximal femur valgus osteotomy and distal femur lengthening needed correction of the proximal angulation, shortening and judicious reaming distally to obtain optimum fixation length. Arrows indicating area of femur canal distortion; F–I: Childhood hip arthritis with significant shortening required extensive release and shortening osteotomy. Distal femoral canal changes with 15 angulation due to prior lengthening had to be managed with careful femur canal preparation for a long modular implant. Orange arrows show the canal distortion. Reaming was done gradually as significant resistance was encountered at that segment. Intraoperative imaging is important in these situations.

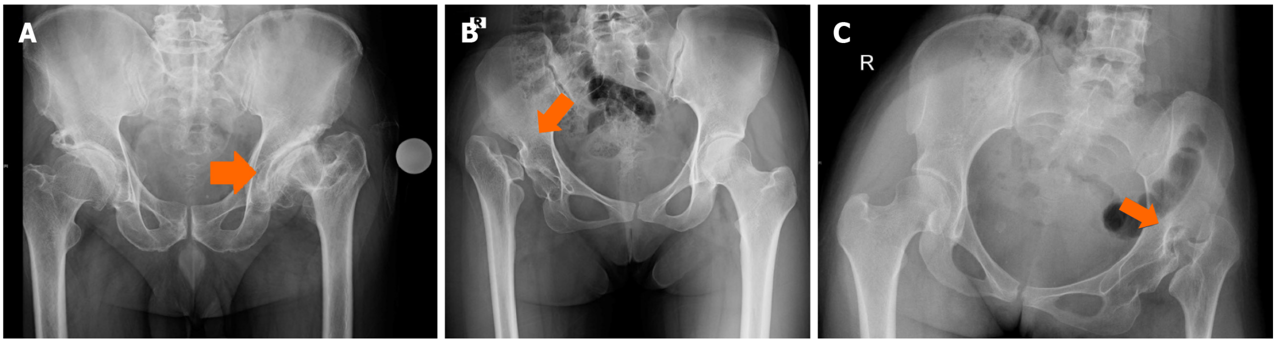

Figure 6 Supratrochanteric shortening: the femoral head is below the level of the greater trochanter, and the lesser trochanter is above the level of the teardrop. A: The left hip; B: Right hip; C: Left hip. The femur head is significantly distorted. Restoration of hip centre would often require adequate soft tissue release and use of primary femoral implants.

Limb length discrepancy is not as significant as seen with DDH. Adults present with decreased movement and increasing pain with functional disability.

The common abnormalities in Perthes sequelae include a large femoral head, often below the level of the greater trochanter and an oblong acetabulum (Figure 12)[6]. Version changes in the femur are expected and must be identified[1,5,15].

Approach and surgical exposure should consider soft tissue releases to fully visualise the acetabulum before initiating reaming to restore the hip COR. Judicious reaming is ensured to avoid eccentric reaming of the walls and correct medialisation after removal of the medial osteophyte. Gradual sequential reaming is advocated for good column capture of the acetabular component. Care is taken not to oversize the acetabular component using pre-operative templating as a guide. The osteophytes are removed around the margins of the acetabulum to prevent impingement after the actual implant is stabilised with screws if required.

The femur is carefully prepared to ensure cortical contact and recognition of any meta-diaphyseal mismatch that could be encountered in Perthes disease. Femoral components could be monobloc or modular as the femoral and acetabular version must be carefully adjusted. Primary femur implants are available with short, standard, and high offset options, and the short neck option is often required in these hips to reproduce the native offset assessed in the contralateral

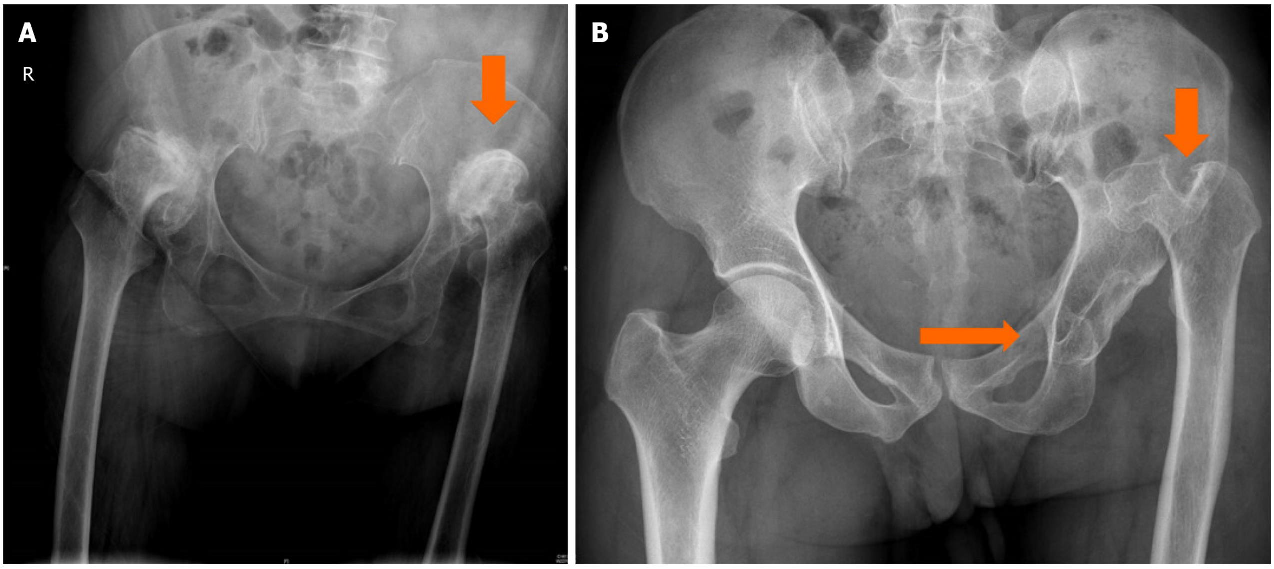

Figure 7 Infratrochanteric shortening: The relationship between the head of the femur and greater trochanter is maintained while the lesser trochanter is above the level of the teardrop (indicated by the arrows). A: Both hips; B: Left hip. Restoration of the hip centre would require identification of the true acetabulum, acetabular centre restoration, and sub trochanteric shortening would almost certainly be required.

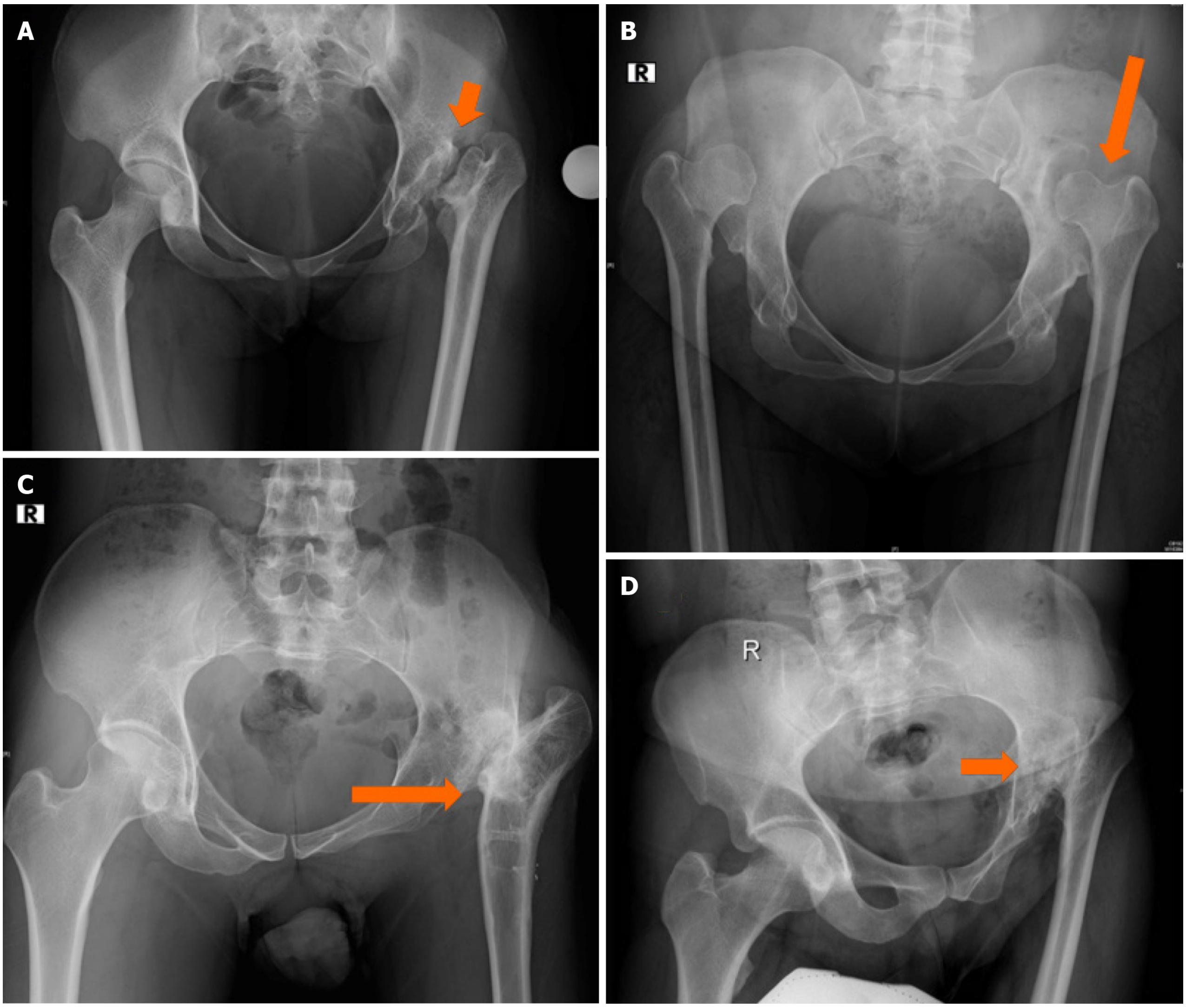

Figure 8 Combined supra- and infratrochanteric shortening. A: Left hip shortening; B: Bilateral shortening due to neglected hip dysplasia; C:

Postoperative proximal femur deformity and shortening; D: Postseptic sequelae in the left hip with shortening of both supra- and infratrochanteric shortening – indicated by the arrows in hips with childhood arthritis sequelae.

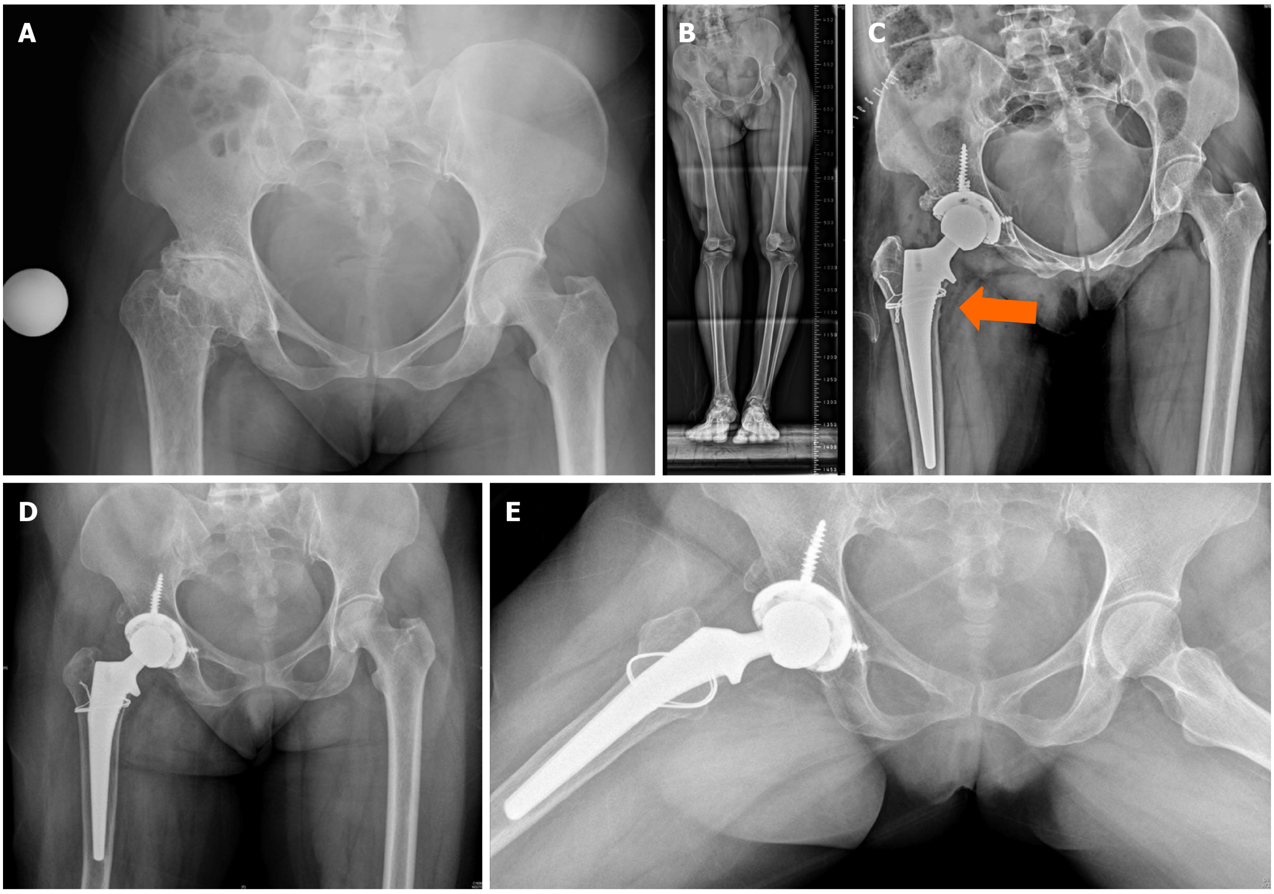

Figure 9 Perthes sequelae hip at total hip arthroplasty with thin femoral cortices. A and B: Femur preparation done with care, however developed crack on trial reduction; C: Stability was achieved with wiring as indicated with the arrow; D and E: Follow-up with restoration of hip centre and well-fixed femur.

normal hip.

Care is taken to achieve optimal fit and stability. The limb length, offset, and combined anteversion are checked after trial reduction, considering the preoperative and intraoperative templating. Femoral version assessment and restoration is essential, and this has been achieved well with standard or short stems[2,5,15]. Hip resurfacing has been described in Perthes, where distortion is not significant[16]. The direct anterior approach has also achieved promising results in hips with Perthes disease[17].

Slipped capital femoral epiphysis sequelae present in adulthood with distortion of the femoral head may be complicated by prior surgical procedures (Figure 13). AP and lateral radiographs with and adjunct CT assessment would provide adequate information regarding anatomical variations before THA.

THA IN CHILDHOOD SEPTIC ARTHRITIS

High riding hips due to postseptic sequelae in childhood present for THA in the fourth or fifth decade with pain, shortening, and a persistent limp. The challenges include soft-tissue scarring, shortening and poorly developed acetabulum[4]. Distal reattachment of the greater trochanter with the abductor has been described earlier to optimise abductor length and function. The high-riding hips would require extensive soft-tissue release and restoration of the COR. Subtrochanteric shortening osteotomy for these high-riding hips with combined supratrochanteric and infratrochanteric shortening combined with acetabular hip centre restoration would restore the leg length discrepancy, offset and normal biomechanics (Figure 14)[4,18,19]. The incidence of these high hips with postseptic sequelae has decreased with better overall health care.

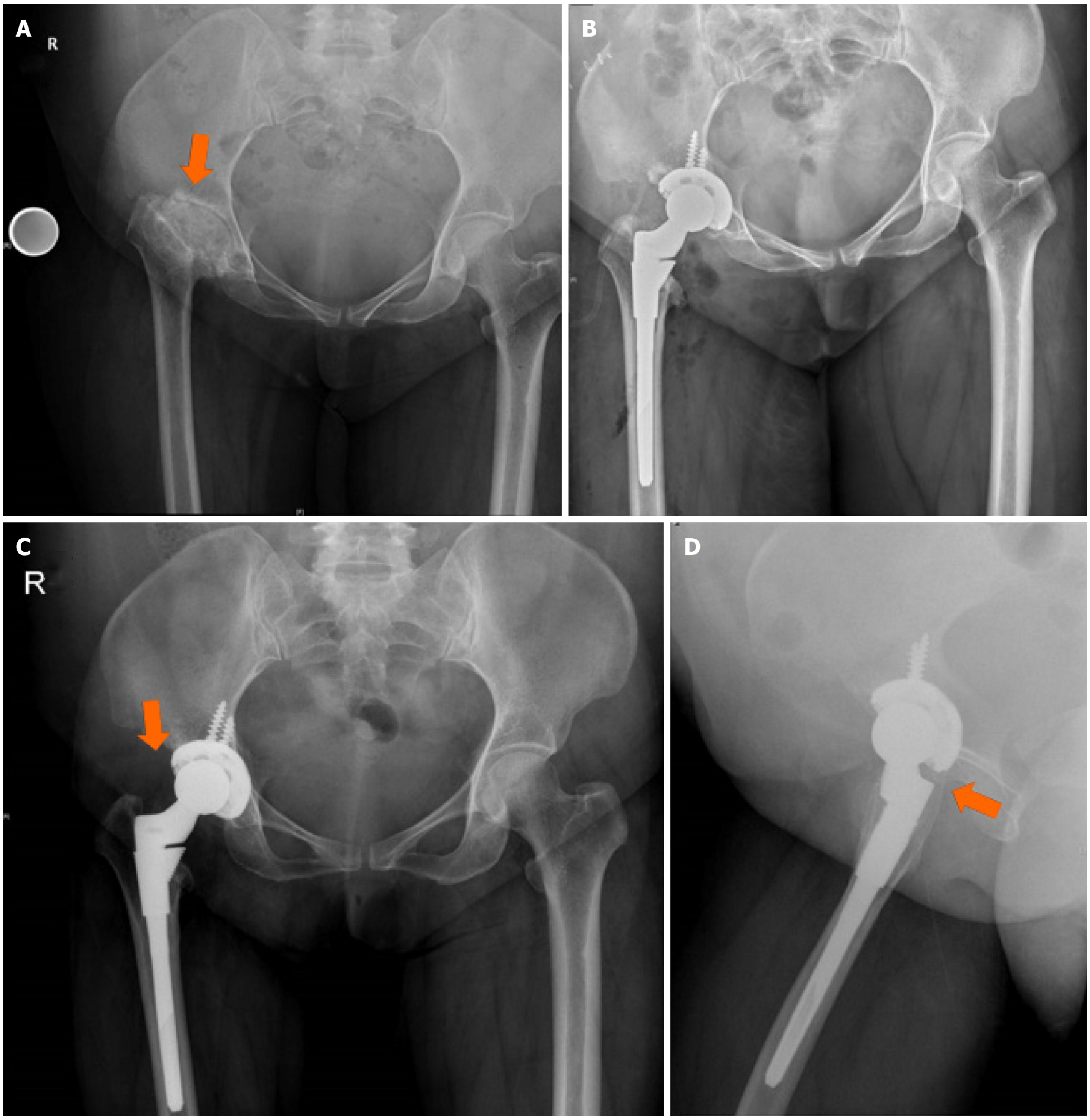

Figure 10 X-ray both hips in a young adult with history of right lower limb shortening and limp since childhood. A: Dysplastic hip sequelae with supratrochanteric shortening and proximal migration; B: Modular stem for neck length and version adjustment; C and D: Follow-up shows restoration of hip centre, offset and length. Arrows show the distortion, offset and the femoral version.

THA AFTER MULTIPLE SURGICAL CORRECTIONS

Containment procedures for the hip are standard practice for dysplastic hips with femoral and acetabular procedures. Femoral correction includes varus derotation osteotomy, valgus osteotomy, and femoral lengthening, which could distort the distal femoral canal. Proximal femur preparation would have to be done with care in hips with altered anatomy due to prior osteotomies (Figures 4 and 12).

Previous acetabular procedures like Chiari osteotomy have improved bone stock for THA. Literature regarding THA after acetabular procedures for childhood hip disorders is limited; however, 5-year survivorship seems good[6].

Restoration of native hip centre and limb length would be ideal. High hip centre with lateralisation can lead to symptomatic early loosening requiring revision (Figure 15).

COMPLICATIONS, OUTCOME

Femoral nerve palsy (1 out of 20) and dislocation (2 out of 20) have been reported following THA with femoral shortening

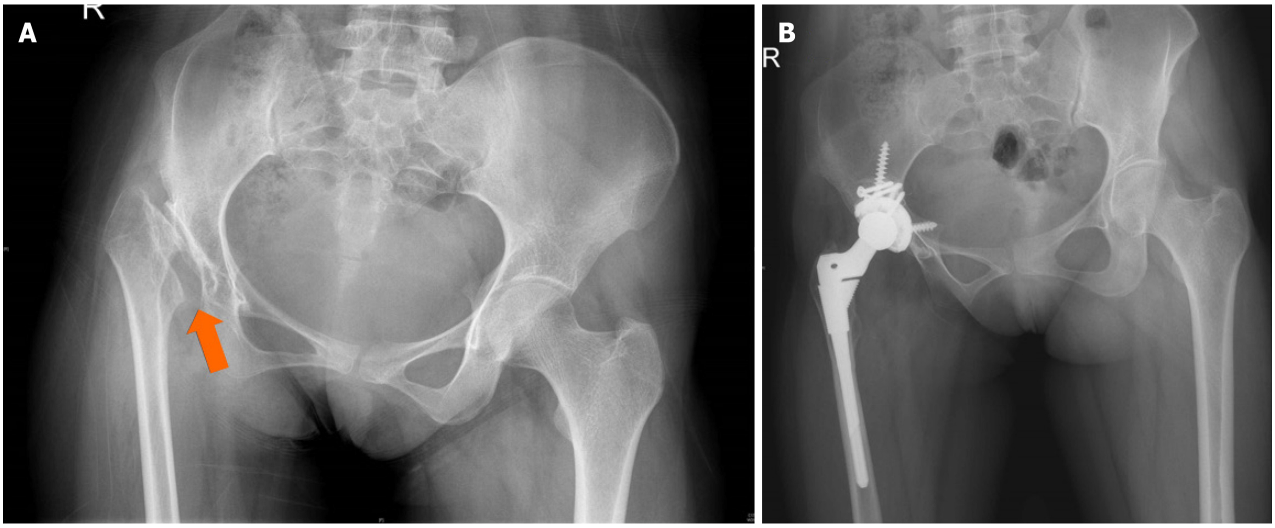

Figure 11 Woman aged 20 years with childhood arthritis of the right hip. A: Infratrochanteric shortening with small size acetabulum (arrow), femur, and narrow canal. Shallow acetabulum with posterosuperior defect was seen on computed tomography assessment; B: Follow up – acetabular centre restoration with small cup, bone graft from head remnant, shortening osteotomy, modular femur with restoration of hip centre and offset.

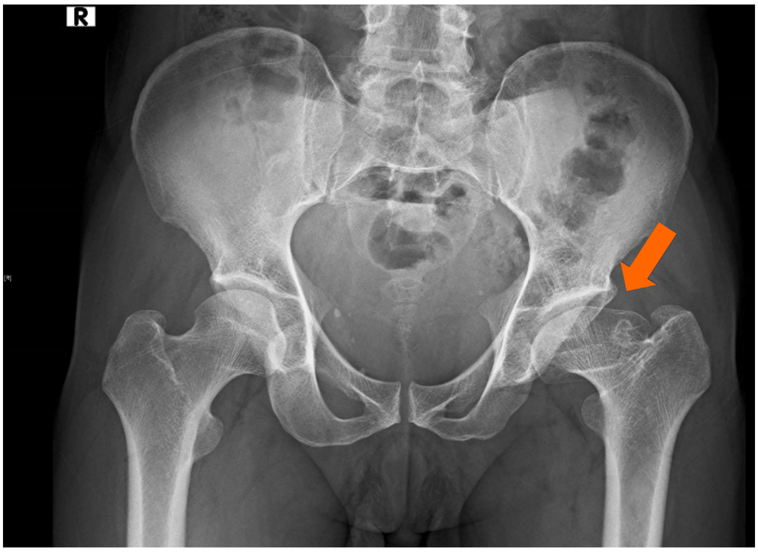

Figure 12 Perthes disease sequelae with flattening of the acetabulum, head deformation (arrow) and shortening. Acetabular preparation, soft tissue release and appropriate femur sizing are required to restore offset and limb length.

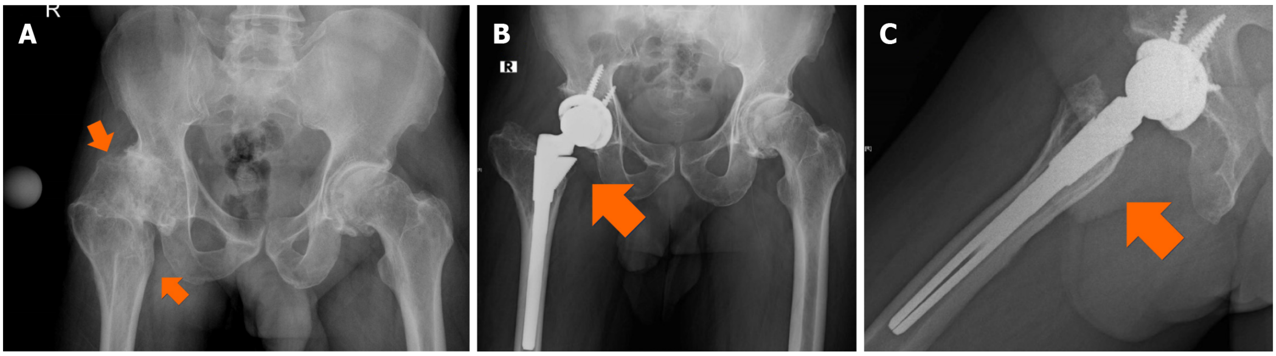

Figure 13 Slipped capital epiphysis sequelae in a 53-year-old man. A: Proximal femur osteotomy done earlier with distortion of the proximal femur anatomy (arrows); B and C: Femur canal entry identification and preparation needs particular attention to achieve stable fixation and reconstruction.

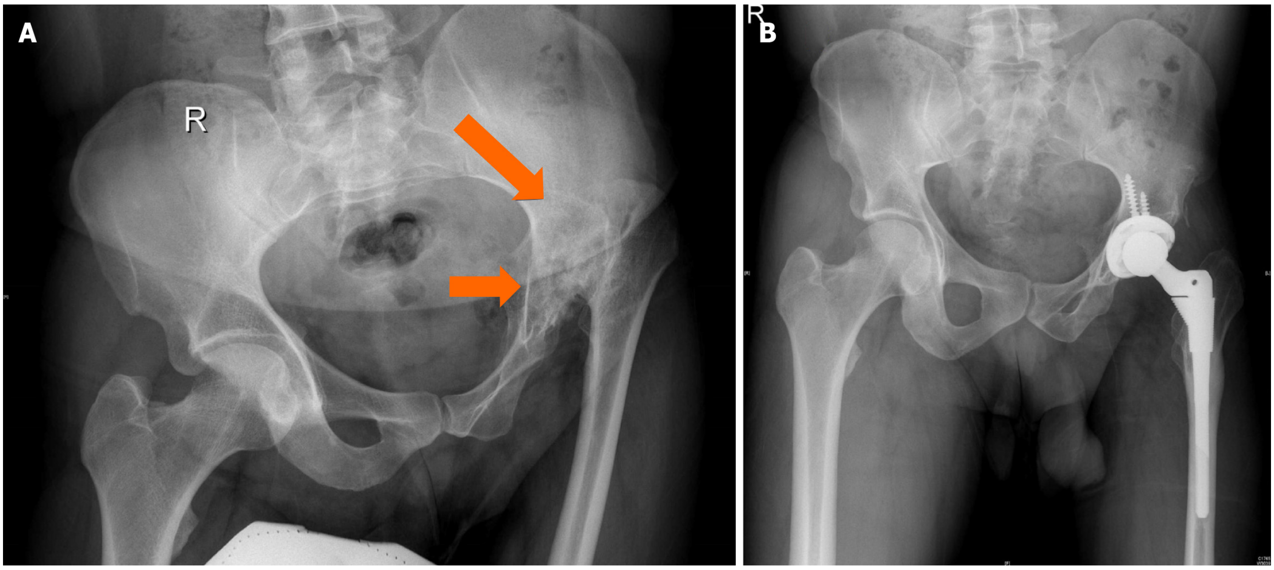

Figure 14 Man aged 39 years with left hip childhood arthritis sequelae. A: Postseptic sequelae with small femur, pelvis and soft tissue changes. The acetabulum and proximal femur (arrows) need proper identification to restore the anatomical centre; B: Follow-up. Identifying the true acetabulum, small acetabular size, soft tissue release, femoral shortening, modular femur, hip centre restoration, neck length and offset requirements are challenging in these cases. This can be achieved with proper preoperative planning and intraoperative assessment.

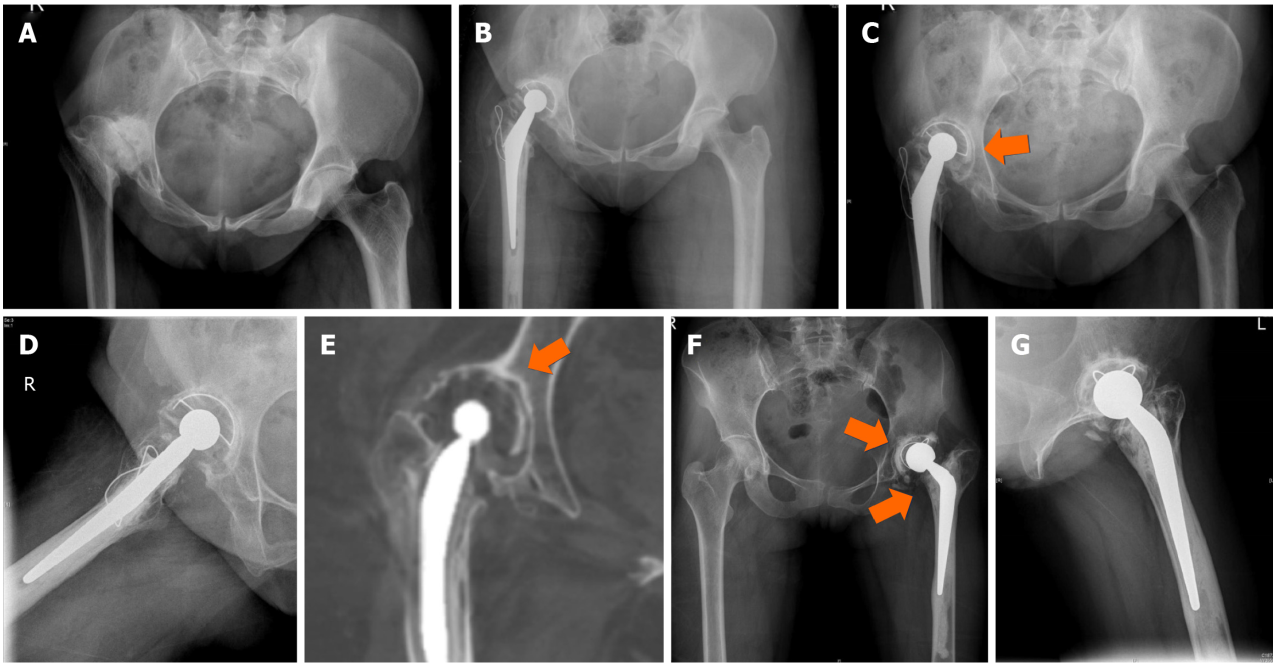

Figure 15 High hip centre/inadequate restoration of hip centre at total hip arthroplasty. A and B: Proximal and lateral migrated dysplastic hip after total hip arthroplasty (THA) with high hip centre. Greater trochanter fracture at reduction stabilised with wiring; C–E: 15-year follow-up with symptomatic acetabular loosening confirmed with computed tomography assessment. This required acetabular revision with hip centre restoration with augments; F and G: Dysplastic hip with cemented THA at 6 years follow-up –proximal and lateralised acetabulum, with reduced neck length and offset femur. Shortening, limp and pain required revision in this hip with acetabular loosening(arrows). Restoration of hip centre, offset was done with true acetabular floor identification, small component, soft tissue release and femur revision.

in severely dysplastic hips[4]. Femoral palsy had recovered, and dislocations were treated by closed reduction with no recurrence[4].

Intraoperative fractures have been reported due to abnormal anatomy (11%–17%) and neurological injury in 3% in a review of literature for THA in Perthes disease[5].

Cemented THA revision rates in dysplastic hips seem to have a slightly increased revision rate (3.3% higher than other groups, with a failure rate of 40% at 25 years)[6]. Acetabular loosening seems to be the leading cause for revision, probably due to the altered anatomy in the dysplastic hips[6]. THA survivorship for high hips has been reported to be 78% at 20 years follow-up[4]. Dislocation rates appear low in these high-riding hips after THA, probably due to hip centre restoration. An overall revision rate of 7% at 7.5 years due to aseptic loosening has been documented for THA in Perthes disease sequelae[5]. Survivorship of 90%–95% has been reported for cementless THA in Perthes disease[2]. An average follow-up of 3.3 years (0.7–10 years) reported good outcomes in another small series with 10 patients who underwent THA for childhood arthritis sequelae[20]. Heterotopic ossification and infection are complications that do occur, with excellent survivorship in THA for postseptic sequelae[13,18]. Recent data suggest good outcomes and survival[3].

CONCLUSION

THA for sequelae to childhood disorders is challenging. Anatomical variations in the acetabulum and femur need careful assessment to plan and restore the anatomical hip COR. Scarring and bony changes from childhood infection or previous surgical procedures must be considered during exposure and reconstruction. Distortion in the anatomy and preservation of native bone stock must be considered during preoperative templating. Having a high suspicion for need of a subtrochanteric shortening osteotomy allows for more efficient intraoperative execution of the preoperative plan. Adequate exposure, soft-tissue releases, and implant option availability for offset and neck length are needed to restore the hip COR and recreate native hip biomechanics.

FOOTNOTES

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