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Current Concepts in The Management of Septic Hip Sequelae in Children

Shobhit Gupta[1] MS(Orth.), Anil Agarwal[1] MS(Orth.)

Abstract

Septic arthritis of the hip can have a serious impact on long term function. From minor changes to severe destruction of proximal femoral anatomy, the spectrum varies. The consequence is altered biomechanics of hip joint leading to pain, limp, instability, stiffness and gait abnormalities. Management of these sequelae has evolved over the years. Less severe sequelae are relatively easy to manage and have reasonably predictable results. Severe sequelae of septic hip, on the other hand pose a significant surgical challenge. Correction of limb length discrepancy, providing stable hips, and elimination of Trendelenburg gait with preservation of hip range of motion should be the main aims in the management of sequelae of the septic hip. Needless to say, even in this era of powerful antibiotics and advanced surgical techniques, early recognition of septic arthritis and timely intervention are of paramount importance in ensuring good long-term hip function.

Keywords: Sepsis; Hip; Sequelae; Choi classification.

Dr. Shobhit Gupta

Dr. Anil Agarwal

Address of Correspondence
Dr. Anil Agarwal,
Department of Pediatric Orthopedics, Chacha Nehru Bal Chikitsalaya,
Geeta Colony, Delhi, India, 110031
E-mail: anilrachna@gmail.com

[1]Department of Orthopedics, Chacha Nehru Bal Chikitsalaya,
Geeta Colony,
Delhi, India. 110031

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Introduction

Septic arthritis of the hip leads to various sequelae in children and some are associated with significant morbidity. The complications associated with septic hip include premature closure of the capital femoral physis, avascular necrosis (AVN) of the femoral head, coxa vara, breva or magna, pseudarthrosis of the femoral neck, hip subluxation/dislocation, complete loss of the femoral head, abductor insufficiency, degenerative arthritis, acetabular dysplasia or ankylosis of the hip [1]. Accordingly, the child may be completely asymptomatic or severely disabled. The management of post-septic sequelae is equally challenging. The numerous classifications available and plethora of techniques described for management of sequelae hip clearly indicate that there is no standard treatment protocol and treatment needs customization according to disease profile and the patient's need.

Pathogenesis of sequelae hips

The infective process damages the developing hip through several mechanisms including direct damage by toxins or through the immune response to infection; tamponade (ischemic) effect, and mechanical failure of pathological bone (Fig. 1). Sepsis destroys cartilage resulting in fibrous or bony ankylosis. The concomitant damage to capsule and stabilizers contribute to instability of the joint. The effect on the physis leads to long term changes in proximal femoral development. The proximal femoral physis contributes to approximately 30% of total femoral length. Complete physeal arrest in early childhood can lead to significant limb length discrepancy. Concomitant joint subluxation or dislocation adds to the amount of limb length discrepancy. Asymmetric physeal growth produces coxa vara, coxa valga or abnormalities of femoral version.

Septic emboli and vascular tamponade cause AVN of the femoral head. Risk of AVN of the femoral head is thought to be greater during the first year of life, because head is largely cartilaginous, although Vidigal reported that AVN is more severe in the older age group [2].

Another mechanism contributing to sequelae is the mechanical failure of pathological bone. The weakened femoral neck due to osteomyelitis may fracture leading to formation of pseudarthrosis. The failure may occur at the epi-metaphyseal junction (physeal slip) or more distally in the metaphyseal or trochanteric region [3].

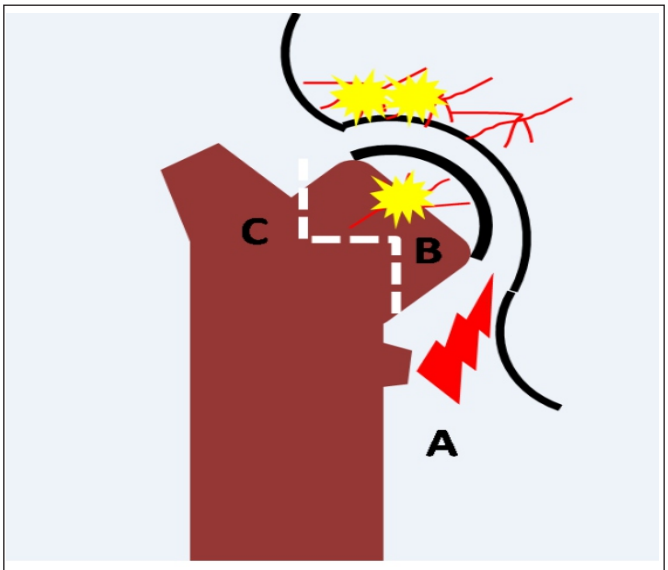

Figure 1: Formation of septic sequelae of hip. A. Direct damage by infectious agent/ toxins/ body's response. B. Tamponade (ischemic) effect. C. Mechanical failure of pathological bone

Incidence and treatment trends

The outcome of hip sepsis depends on the extent, severity and duration of the disease process. Delay in treatment also leads to poor outcomes. Various studies report poor outcome or unsatisfactory results following septic arthritis in form of avascular necrosis, chondrolysis or loss of head in 9% to 66% cases [4].

With improvement and advancement of health care and surgical techniques, better outcomes have been reported in septic sequelae. A review of the most recent series describing sequelae of septic hip and their outcomes is included in Table 1 [5-9]. Several new procedures like osteochondroplasty, Illizarov hip reconstruction and others have been introduced. Procedures where results were unsatisfactory or unpredictable like greater trochanteric arthroplasty have lost favour over time. The current trend favours individualization of treatment based on presence of femoral head, its profile and stability, nature and severity of symptoms and the patient's functional demands.

Classification of post-septic hips

Various radiological classifications of septic sequelae are proposed to describe the late hip changes and guide treatment [6-9,13]. Hunka classified septic sequelae into 5 categories based on 10 patients over an 11-year period [7] (Fig. 2). Choi et al modified Hunka's classification and classified septic sequelae based on experience of 34 hips of 31 patients [6] (Fig. 3 and 4). More recently, Forlin and Milani classified 41 hips in 37 patients based on relation between the femur and the acetabulum and sub-divided them according to the appearances of the proximal femur [8]. Johari's classification is based on joint stability and the presence or absence of the capital femoral epiphysis [13].

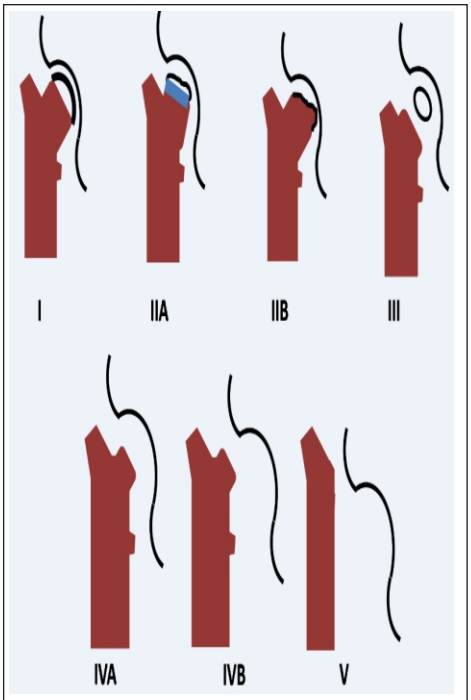

Figure 2: Diagrammatic representation of Hunka's classification of sequelae septic hips. Five types.

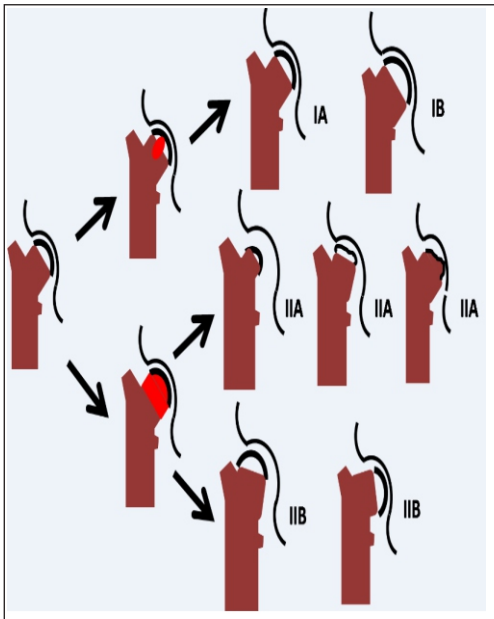

Figure 3: 1. Diagrammatic representation of Choi's classification of sequelae septic hips. Type I: affected region is proximal femoral epiphysis and physis. Type II: affected region is epiphysis, physis and metaphysis

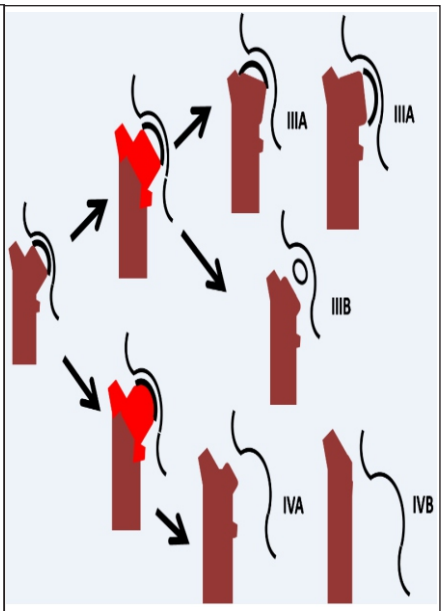

Figure 4: Diagrammatic representation of Choi's classification of sequelae septic hip. Type III: affected region is femoral neck. Type IV: affected region is epiphysis, physis and metaphysis

Table 1: Sequelae of septic hip in children: most cited series in literature

Study	Age at surgery (years)	Mean follow up (years)	Number of hips	Onset of disease	Type of sequelae	Outcome
Hunka, et al.,1982	14.2	11.2	10	Before 18 months -9, after 18 months -1	Hunka type III - 2, Type IVA -2, Type IVB -3, Type V- 3	Type III -2 (Unsatisfactory), Type IVA -2 (satisfactory) Type IVB -3 (satisfactory), Type V- 3 (satisfactory)
Choi et al., 1990	IIIA -6, IIB- 4.8, IVA - 4.9, IVB -6.6	**IIIA -9.3, IIIB -9.9, IVA- 10.2, IVB- 9.4**	45	—	Choi type IIIA - 10 Type IIIB - 3 Type IVA - 14 Type IVB- 18	Type IIIA - Satisfactory - 90% Type IIIB - Satisfactory - 66.66% Type IVA - 1) 58.33% (7/12) satisfactory in Harmon procedure, 2) unsatisfactory in Colona arthroplasty Type IVB- 1) Trochanteric arthroplasty - Below 6 years age - satisfactory in 71%; above 6 years age - unsatisfactory in all 2) Ilizarov hip reconstruction - Satisfactory in all 3) Vascularized Iliac crest graft- unsatisfactory 4) Soft tissue release - unsatisfactory
Betz et al.*, 1990	-	<3 months: 32; >3 months: 25-64	<3 months group - 19, >3 months group - 13	1) <3 months age group 2) >3 months age group	<3 months group -Hunka type I -2, IIA -2, IIB- 2, III -3, IVA -5, IVB -1, V-4; >3 months group -Hunka type I -1, IIA -2, IIB – 2, III -0, IVA -3, IVB -1, V-4	<3 months age group - Mean HHS – 71 Excellent -8 (Type I -2, Type IIA - 2, Type III -2, Type V - 2) Good -2 (Type V -2) Fair- 1 (Type IIB -1) Poor -8 (Type IIB -1, Type III-1, Type IVA -5, Type IVB- 1); >3months age group - Mean HHS – 69 1); >3months age group - Mean HHS – 69 Excellent -2 (Type I -1, Type IVB-1) Good -0 Fair- 4 (Type IIA -2, Type V- 2) Poor -7 (Type IIB -2, Type IVA -3, Type V -2)
Wada et al., 2007	IIIA -4.2, IIIB - 3.3, IVA, IVB - 4.2	8.9	IVB - 5	-	Choi types III and IV	Type IIIA - 8/11(satisfactory) Type IIIB- 2 had union, 2 - nonunion Type IV – 2/6 (satisfactory)
Forlin and Milani, 2008	-	6.9	41	25(61%) neonates; 16 (39%) at 1 month- 3 years	Forlin and Milani classification 1A - 10, 1B -11, 2A - 3 2B - 17 ,	24 - satisfactory, 17 - unsatisfactory

* Except for Betz's study, the criteria used for clinical outcome is Hunka; for this series Harris hip score (HHS) was used.

Table 2: Different classifications of sequelae of septic hip with reference to Choi's classification*

Hunka (1982)	Choi (2006)	Forlin and Milani (2008)	Johari (2011)
I	IA	-	-
Minimal or no femoral head changes	Almost normal hip		
IIA	IB	-	4
Deformity of the femoral head with an intact physis	Almost normal hip with mild coxa magna		Articular incongruity, avascular necrosis, coxa magna, physeal disturbance (coxa brevia/ vara/ valga and trochanteric overgrowth) (Stable)
IIB	IIA	1A Femoral head within acetabulum and total or part of femoral head present /	1
Deformity of the femoral head with premature fusion of the physis	Coxa breva, flattening and irregularity of the femoral head, femoral neck may be short and wide, relative overgrowth of trochanter	1B	Loss of capital femoral epiphysis/ neck, metaphyseal spike present (stable)
IVA		Femoral head within acetabulum and no femoral head present	3B
Complete destruction of the proximal femoral epiphysis with a stable neck fragment			Subluxation, capital femoral epiphysis present
IIB	IIB	1A	4
	Progressive coxa vara/valga,		
	flattening and irregularity of the femoral head, femoral neck may be short and wide, relative overgrowth of trochanter, coxa magna may be associated		
IIA	IIIA	1A	4
	Angular		
	deformity with severe anteversion or retroversion		
III	IIIB	1A	5
Femoral neck pseudarthrosis	Pseudarthrosis		Pseudarthrosis of femoral neck (stable/unstable)
IVB	IVA	2A	3A
Complete destruction of the proximal femoral epiphysis with a small unstable neck fragment	Unstable persistent remnant of the femoral neck	Hip dislocated and total or part of femoral head present	Dislocation, capital femoral epiphysis present (unstable)
			3B
			Subluxation, capital femoral epiphysis present (unstable)
V	IVB	2B	2
Complete destruction of the head and neck to intertrochanteric line with dislocation of hip	Complete loss of the femoral head with no vestige of an articulation	Hip dislocated and no femoral head present	Loss of capital femoral epiphysis and neck (unstable)

*Approximate; based on available descriptions from original text

A comparative analysis of the above classification systems is presented in Table 2. Choi's classification is perhaps the most often quoted classification for post-septic hips.

Clinical presentation

A child with hip septic sequelae may be completely asymptomatic. The symptoms may be delayed due to late manifestations of infection e.g. growth arrest, acetabular dysplasia. The main presenting complaints are pain, limp, restriction of movements and instability. Pain may be due to instability, abnormal bony anatomy, ankylosis, incongruent joint surface or premature degenerative changes. Limping can occur because of coxa vara, dysfunctional abductor mechanism, pseudarthrosis, shortening, instability and pain. Restricted range of motion can result from multiple reasons viz. premature closure of the triradiate cartilage, acetabular dysplasia, avascular necrosis of the femoral head, soft tissue contracture, misshapen head and incongruency or ankylosis. Sometimes, multiple pathologies coexist and are together responsible for symptoms. With time, secondary changes may occur in the spine and distal joints.

Management

Various treatment modalities have been described to manage post-septic hip sequelae. The principal objectives of treatment and common ways of achieving them include: [15,16]

1. Improving head coverage - Abduction cast or brace, open reduction, femoral and/or pelvic osteotomy, osteochondroplasty
2. Limb length equalization - Shoe raise, contralateral epiphysiodesis, ipsilateral limb lengthening

3. Improving abductor insufficiency - Trochanteric arthroplasty, neck lengthening procedures (Wagner femoral neck lengthening, Hasler and Morscher's modification of Wagner's osteotomy, Papavasiliou technique, Kruminis modified Illizarov technique etc.), distal lateral transfer of greater trochanter, femoral and/or pelvic osteotomies

4. Providing stable hip - Closed/ open reduction, femoral and pelvic osteotomies

5. Restoring alignment - Femoral and/or pelvic osteotomies

6. Achieving union in pseudarthrosis - valgus osteotomy with or without fibular grafting

7. Salvage procedures- arthroplasty, fusion.

8. Special procedures for loss of head and neck (Choi type IV A and B)

a. Albee, L'Episcopo and Harmon described similar procedures in younger children with severe sequelae of suppurative arthritis (Choi types IVA and B) [18-20] (Fig. 5). Albee arthroplasty was originally described for non-union neck femur by excising the head of femur and placing the denuded portion of greater trochanter into the acetabulum, thus creating a longer neck for better abductor function [18]. Modified Albee arthroplasty involves removal of greater trochanter and creating an incomplete greenstick fracture at base of medial fragment while maintaining the normal neck shaft angle between medial fragment and proximal femoral shaft [12]. It is said to restore near normal anatomy of hip, equalize limb-length discrepancy and prevent trochanteric overgrowth. However, proximal femoral portion may show poor remodelling, thus causing instability of hip joint with positive Trendelenburg test. There is also a theoretical risk of AVN.

L'Episcopo (1936) slit the proximal remnant end of the femur and directed the medial half into the acetabulum [19]. Choi et al used modified Harman procedure to produce neck lengthening effect in hips with a preserved cartilage cap [11]. An incomplete, open wedged osteotomy was made at the base of the proximal femoral remnant adjoining the greater trochanter. Open wedge defect was filled with cartilaginous bone graft from the iliac crest.

b. Greater trochanteric arthroplasty (Fig. 6). In Colona arthroplasty, fibromuscular layers over the greater trochanter are preserved by avoiding subperiosteal dissection [21]. The remaining neck portion is removed up to the femoral shaft. The greater trochanter is positioned into the hip joint. The abductors are reattached over the lateral aspect of the femur after maximum advancement. It can be combined with varus osteotomy of the femur. Greater trochanteric arthroplasty is a salvage procedure and decreases limb length discrepancy and pain, provides better hip function, gait and stability. Long term complications are subluxation due to gradual remodelling of the proximal femoral angulation, pain, avascular necrosis of proximal fragment, non-union, and stiffness. Choi et al introduced muscle pedicled trochanteric arthroplasty and preserved the vascularity of proximal femoral segment by not

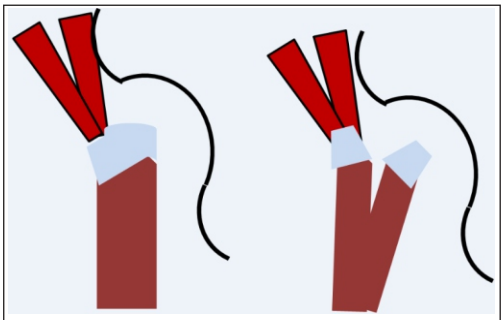

Figure 5: A,B. Choi IV sequelae. Diagrammatic representation of basic principle in Albee, L'Episcopo and Harmon procedure. The child should be young at the time of procedure. The proximal available portion of femur is split and medial part is inserted into acetabulum for formation of a femoro-pelvic articulation.

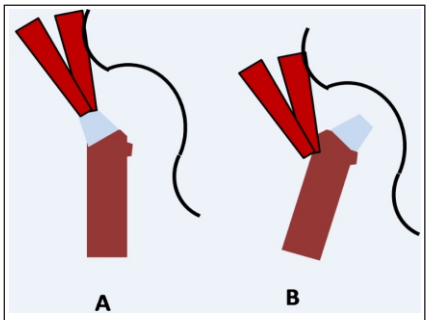

Figure 6: Diagrammatic representation of trochanteric arthroplasty: A, B. The trochanter is freed of all attachments and placed deeply within the acetabulum. Abductor muscles are transferred distally. Often proximal femoral varus osteotomy and/ or acetabular procedure is added.

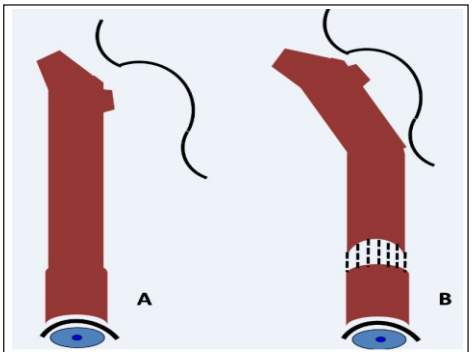

Figure 7: Diagrammatic representation of pelvic support osteotomy and hip reconstruction: A,B. The proximal pelvic support osteotomy is usually made at the ischium level. The distal realignment osteotomy is combined with limb lengthening procedure.

detaching the origin of vastus lateralis and intermedius [16].

c. Cheng used vascularized iliac crest graft in 7 children (8 hips) with Choi type IVB sequelae. Five hips showed graft resorption and only 3 cases showed graft remodelling [22].

d. Ilizarov hip reconstruction (Fig. 7) - Provides stability of hip, eliminates abductor lurch and corrects limb length inequality.

Age consideration for surgical intervention

Stable hips with deformed/ malaligned proximal femoral anatomy can be simply observed. Lateral extrusion of femoral head, abductor insufficiency and acetabular dysplasia should be treated by femoral varus/valgus with/without derotation osteotomy and pelvic osteotomies at an appropriate time. Concomitant soft tissue release should be done to improve mobilization of hip.

Freeland et al advised surgery at or near skeletal maturity [23] whereas others [6,7,20] proposed age less than 2 years as appropriate for surgery.

Closed reduction of dislocated hips with preserved head can be tried up to 2 years of age [13,17]. After 2 years, open reduction is recommended. Choi et al believe that open reduction reduction in children older than 6 years of age is not likely to be beneficial because of a high risk for stiffness and pain [16]. In older children, these hips should be treated similar to Type IVB.

Ilizarov hip reconstruction should be reserved for severe type of sequelae and should be undertaken in the adolescent years. Choi recommended pelvic support osteotomy even after 6 years of age, in failed reconstructive procedures in type IVA and in type IVB sequelae because it improves abductor mechanism, provide better muscle strengthening and a repeat pelvic support osteotomy can be performed at later age, if required [16]. He recommended abductor muscle strengthening exercise with shoe lifting in children who are candidates for later hip reconstruction pelvic osteotomy. Loss of pelvic support has been reported in young children as early as 12 months after the procedure due to remodelling [24]. Some authors therefore recommend Illizarov hip reconstruction for skeletally mature adolescents and for young adults [24].

Prognostic factors for sequelae

Prognostic factors for septic sequelae are [1, 5, 8, 15, 16, 25, 26]:

1. Age at onset
2. Delay in hip drainage
3. Virulence of the causative organism
4. Prematurity
5. Associated osteomyelitis
6. Septic dislocation

Betz et al described poor outcomes in children where the hip sepsis occurred at less than 3 months of age and when there was a delay in drainage of greater than 4 days from the onset of sepsis [5, 8]. Non-staphylococcal organisms may be less destructive to the femoral head in infants [25].

Due to advanced modalities of early detection of septic hip and better treatment, Lee et al described different prognostic factors from those previously described [26]. In his study, only the duration of symptoms before surgery was associated with a worse radiological prognosis. Both neonate and infant groups had no significant difference in prognosis. Delay of 5 days from onset of infection to treatment resulted in radiological unsatisfactory outcomes in 50% of cases. Poor clinical prognosis was not found to be associated with underlying disease, young age, concomitant osteomyelitis, infective organism and even with duration of delay in management.

Authors' preferred method of treatment for sequelae hip (Table 3)

The authors' preferred treatment protocol for various Choi types is presented in table 3.

Types IB, IIA and B, IIIA are treated according to the severity of deformity (Fig. 8,9,10).

For Type IIIB, we take into consideration two factors: progressive coxa vara and child's age. If coxa vara worsens further than 90-100 degrees and the age is more than 4 years (neck profile sufficient to permit

fibular strut graft), intervention is considered (Fig. 11).

We usually intervene early in Choi IVA sequelae if a cartilage cap is present and prefer open reduction as true anatomical characteristics and head shape are visible only by direct visualisation of the femoral head. Post reduction stability can be judged simultaneously and if required, concurrent femoral and pelvic osteotomies can be added (Fig. 12).

For type IVB, the child is offered pelvic support osteotomy early if he/she has presented before age 6. The procedure provides hip stability and limb equalization. Even if the osteotomy remodels, the child has much better gait characteristics in early years of childhood. A repeat procedure, if required, can be offered at skeletal maturity. We do not hesitate to equalize limb length at any age (shoe raise/contralateral epiphysiosdesis/ ipsilateral lengthening) because it aligns pelvis, prevents secondary compensatory mechanisms and reduces energy expenditure for walking.

Conclusions

Septic arthritis of the hip results in different sequelae according the region involved and severity of the original insult. Although the outcomes are variable and unpredictable, timely intervention in select cases can help achieve good joint stability, better proximal femoral anatomy and gait improvement. In other cases, reconstructive procedures may help in minimizing limb length discrepancy and in delaying the need for total hip arthroplasty or salvage surgery.

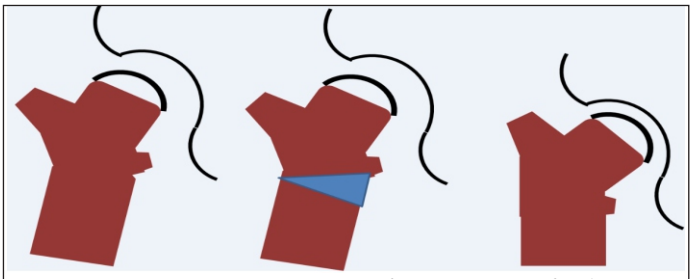

Figure 8: Diagrammatic representation of varus osteotomy for alignment problems of proximal femur. The derotation may be performed concomitantly if version problems coexist.

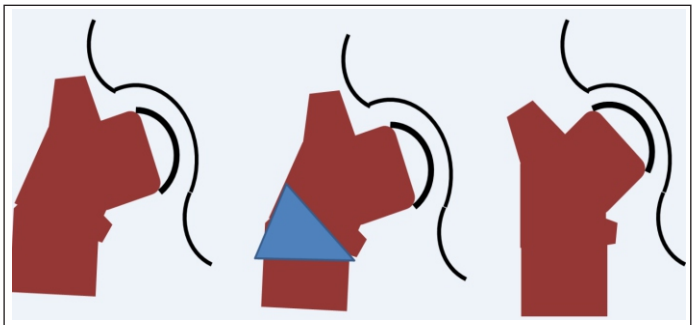

Figure 9: Diagrammatic representation of valgus osteotomy for alignment problems of proximal femur. The derotation may be performed concomitantly if version problems coexist.

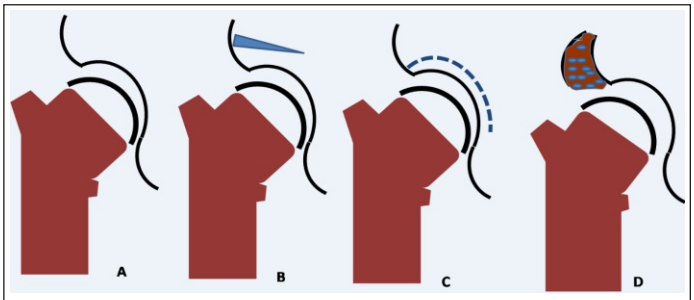

Figure 10: Diagrammatic representation of various types of acetabular procedures for A. dysplastic acetabulum. B. Reorientation osteotomies like Salter/ Dega or other modifications. C. Pericapsular Pemberton or other modifications. D. Enhancing coverage: Shelf. Sometimes other salvage

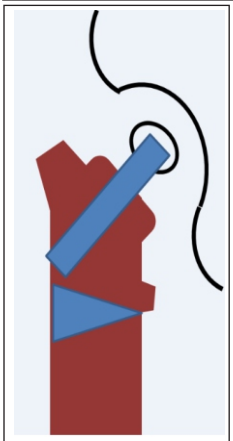

Figure 11: Diagrammatic representation of treatment in Choi IIIB pseudarthrosis: Valgus osteotomy with or without bone grafting.

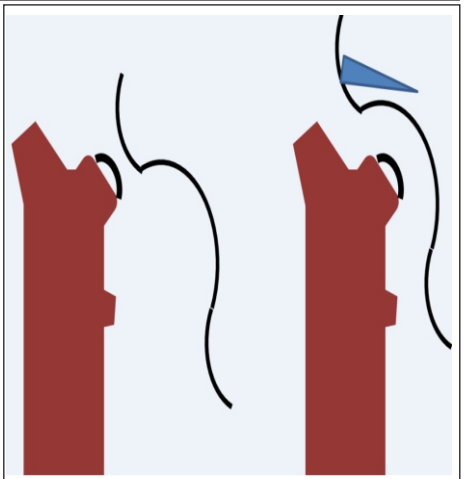

Figure 12: Diagrammatic representation of treatment in Choi IVA sequelae. If reasonable size articular cap is present and child is young, open reduction is preferred. Additional procedures like pelvic and femoral osteotomy may be required to ensure reduction stability.

Table 3: Authors'preferred method of treatment for sequelae hip^

Choi type	Treatment	Indication
I	Observation or abduction cast/orthosis	Mottling, fragmentation or delay in ossification of the femoral head epiphysis
II	Femoral varus/ valgus osteotomy	Coxa vara/ valga/ coxa magna
	Acetabular procedure	Hip subluxation, acetabular dysplasia, coxa magna
	Greater trochanteric epiphysiodesis	Trochanteric overgrowth
	Neck lengthening procedures; distal trochanteric transfer	Severe coxa breva
IIIA	Femoral varus/ valgus osteotomy, derotation, acetabular procedure	Coxa vara/ valga with retroversion or anteversion
IIIB	Observation for coxa vara; femoral valgus osteotomy with bone grafting	Pseudarthrosis
IVA*	Open reduction combined with or without femoral and pelvic osteotomy	Presence of adequate cartilaginous cap over neck remnant and child is below 6 years of age
	Supervised neglect; compensation for limb length discrepancy	Adequate cartilaginous cap absent
	Pelvic support osteotomy and reconstruction	After 6 years age #
IVB*	Supervised neglect; compensation for limb length discrepancy	Child is below 6 years age
	Pelvic support osteotomy and reconstruction	After 6 years age #

* trochanteric arthroplasty has fallen into disfavour because of unpredictable results
^ limb length discrepancy can be associated with any sequelae type
# may require a repeat procedure, if performed early

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