ABCD'S of Reconstruction after Childhood Osteomyelitis

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Childhood Osteomyelitis leads to five main problems

Growth **A**rrest
Bone Gaps
Contractures of Joints
Deformities of limbs in all planes
Shortening of the Limbs.

As a Paediatric limb reconstruction surgeon one sees all five of these manifestations in various combinations very regularly. Though the blight of osteomyelitis has dramatically reduced of late, even minor alterations in the functioning of the growth plate can lead to dramatic amounts of all these five effects.

Let us see how all can be tackled, using either routine & general Orthopaedic techniques as well as the very powerful and elegant Ilizarov techniques.

Growth Arrest

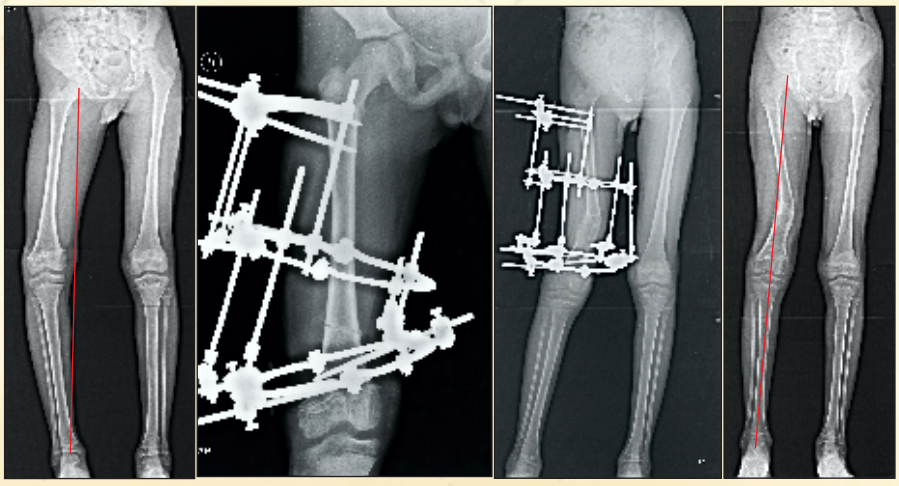
Physeal Arrest is perhaps the commonest side effect of childhood osteomyelitis. In the vast majority infection leads to retardation of the growth plate, either partially or wholly : leading to deformities in all planes and shortening. In a small minority, juxta-physeal infection can lead to growth stimulation and cause lengthening of the affected limb, with or without mild deformities.

Physeal Arrest may be subtle or gross in its manifestation. A physeal bar is a variably sized bridge of bone from the metaphysic across the phasis to the epiphysis. It is also called Premature Partial Physeal Arrest or Closure. This bar tethers the growth of the remaining normal physis, which results in deformities of the physis, metaphysis and epiphysis, angular & rotational deformity and shortening.

A Physeal Bar Equivalent (PBE) is the result of physeal cell death in a portion of the physis resulting in similar effects as a bar without a physical bar crossing the physis.

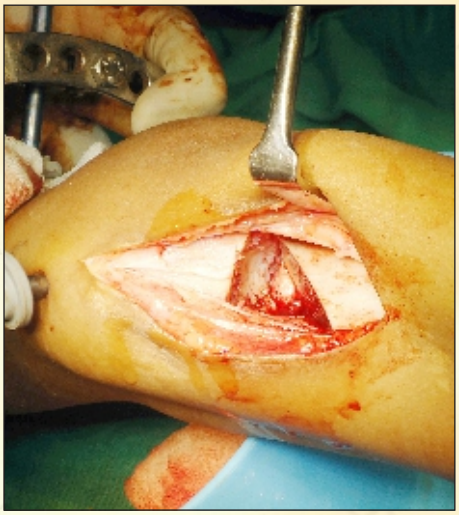
Physeal bar excision is a method which relies on detecting the location of the physeal bar (or growth plate scar) either on plain x-rays or ideally on MRI scans. Excision of the physeal bar by itself will fail as the bar re-forms. The use of Inter-positional material prevents reformation. Bone Cement has many advantages: it can be moulded and stays put in the location of the bar.

Existing deformities need correction by osteotomy and shortening by limb lengthening. The osteotomies may be performed as a open wedge, close wedge or neutral wedge and fixed by K wires. However it is ideal to perform lengthening and deformity correction using the Ilizarov fixator. Towards the end of treatment, this may be taken to its logical conclusion by over lengthening and over correction of the deformity.



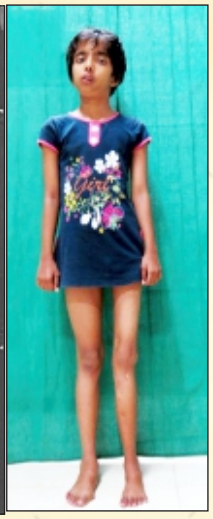
A simple strategy for growth arrest with angular deformity and shortening is to perform lengthening and deformity correction or overlengthening and overcorrection. The Ilizarov corticotomy creates a new physis anywhere in the bone. The zig-zag appearance in this postop x-rays will remodel with time.





A comprehensive strategy for severe growth arrest is to attempt physeal bar excision, shown here by removing a triangular piece of bone to access the physeal bar that is located on x-rays and MRI. The triangular piece removed temporarily to give clear access to physeal bar which is excised and cement is inserted.



In the same surgery, Ilizarov apparatus is applied and lenghtening through the lower part of triangle is achieved to desired extent. Here we also lengthened through an upper femoral corticotomy. Finally she is overlengthened and overcorrected to compensate for future deformity.

Bone Gaps

Bone gaps may be caused by sequestration and dissolution of infected bone or be debridement. Bone gaps following osteomyelitis can be very disconcerting and difficult to treat.

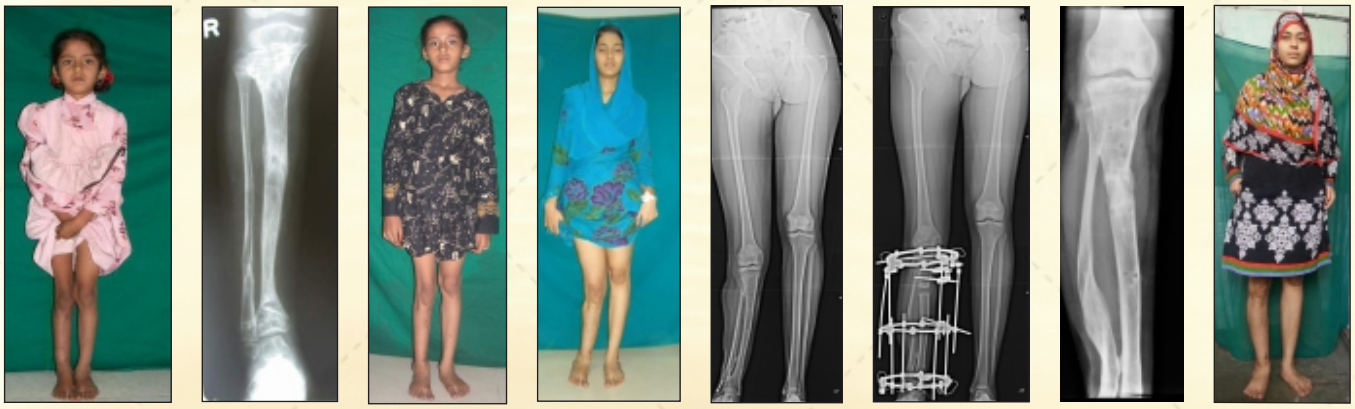
Traditional methods rely heavily on using the fibula to fill bone gaps. In the upper extremity, the non-vascularized fibula can very nicely be used to fill defects in the Humerus and Radius. In the femur, too a non-vascularized fibula does well to fill gaps when it is interposed and invaginate in ends of proximal and distal canal. In the tibia, it may be used as a Huntington's procedure as an acute translocation of the fibula along with its vascular pedicel.

All these methods have the great advantage of simplicity but usually leave some aspect of the problem unsolved. Most commonly partial correction of the deformity and residual shortening are common problems. It is also not unusual for one of get ends of the fibula to not unite. This may happened in upper as well as lower extremities. The limb has to be protected in a cast and child kept in bed rest and not allowed to walk until the fibula incorporates strongly which leads to loss of schooling, play and normal development of the child.

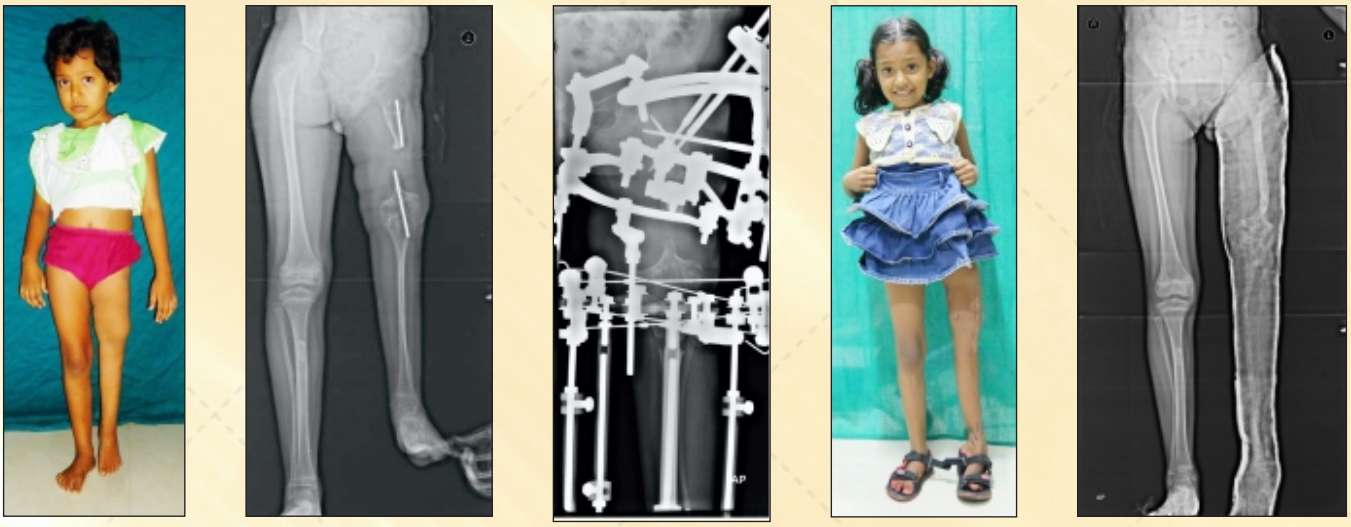
It is far better to use the Ilizarov fixator to initially gradually distract the upper extremity (either Humerus or radius or ulna) out to length and then insert the non-vascularized fibula. It enables restoration of length, correction of deformity and stable fixation, use of the extremity and certainty of union.

In experienced hands the Bone Transport technique using the Ilizarov or LRS fixator is a very reliable method of filling bone gaps with less physiological cost. It is a per cutaneous surgery with little blood loss. Though time consuming the transported fragment docks well at the end of the gap and union can be achieved most often without the use of Bone Grafting. The patient is also ambulatory during treatment. Limitations include the need for expertise, pin site care, frequent follow-ups and possible joint stiffness in knee and ankle joints. It is most suited to the lower extremity. Very large bone gaps can be filled with certainty.

15 month old child with severe bone loss due to osteomyelitis along with deformity and shortening. Initial Ilizarov apparatus used to increase gap and bring tibia out to length. other's fibula used to fill gap. 2nd lengthening done after 5 yrs.



Serial photos of child growing up. One surgery done for epiphyseodesis of lower fibula to prevent its deformity. One more surgery done for lengthening at age 10. Finally, last lengthening @ maturity to equalize and correct residual deformities.



Severe bone gap due to osteomyelitis and shortening. Ilizarov bone transport in femur and lengthening of tibia to fill the gap as well as to lengthen to almost equal lengths.

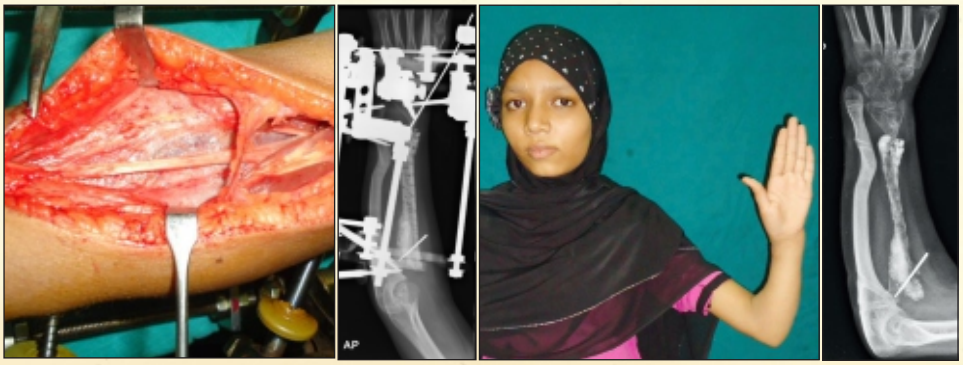
Contractures

Contractures of the joints develop due to malpositioning as well as soft tissue defects due to osteomyelitis.

Mild contractures are best corrected with serial casting or when possible with soft tissue releases.

However when the contractures are stiff and the tissue is fibrous and dense and not amenable to open release a gradual distraction using the Ilizarov fixator will completely correct the contracture. Another advantage is that the Ilizarov will enable simultaneous correction of a bony deformity as well as lengthening.

Significant wrist contracture and manus valgus deformity due to gap in the Radius due to osteomyelitis. Ilizarov applied in 1st stage to correct deformity, contracture and bring distal Radius out to length.



. In 2nd stage, non-vascularized Fibula inserted into the gap. Deformity almost completely corrected.

Deformities

Deformity correction is now a recognised sub-speciality of Orthopaedic surgery. The 1st Generation of Deformity correction started with Nicholas Andry (who coined the term Orthopaedics) in the 18th century. It consisted of deformity correction using osteotomies(mostly closing wedge) which were performed empirically, without due regard to joint line orientation or mechanical axis deviation. The advent of the Ilizarov techniques in 1980's allowed the development of Deformity correction as a speciality with rules of deformity correction being laid down and the ability to comprehensively correct angular, rotational and translational deformities as well. The RISC RTO institute in Kurgan (the birthplace of the Ilizarov technique) has done yeoman service to this science with "Transosseous Osteosynthesis" tome establishing the science with great depth. "Principles of Deformity correction" authored by Paley made great strides in the analysis of deformities, be they in the coronal, sagittal or oblique planes as well as in the axial plane (shortening). Rules of Deformity correction analyse the apex of the deformity, explain the location of hinges for correction, location and shape of the osteotomy, orientation the joint line, translation at the osteotomy and effect of correction on the mechanical axis .

The 3rd generation of deformity correction started in the early 2000's with advent of the TSF(Taylor Spatial Frame) fixator . it is a software controlled fixator which relies on inputs of angles & measurements in a software to create a program. ^ struts which represent the 6 axes (± X, ±Y and ±Z) help correct the most complex of deformities without the need for extensive analysis.

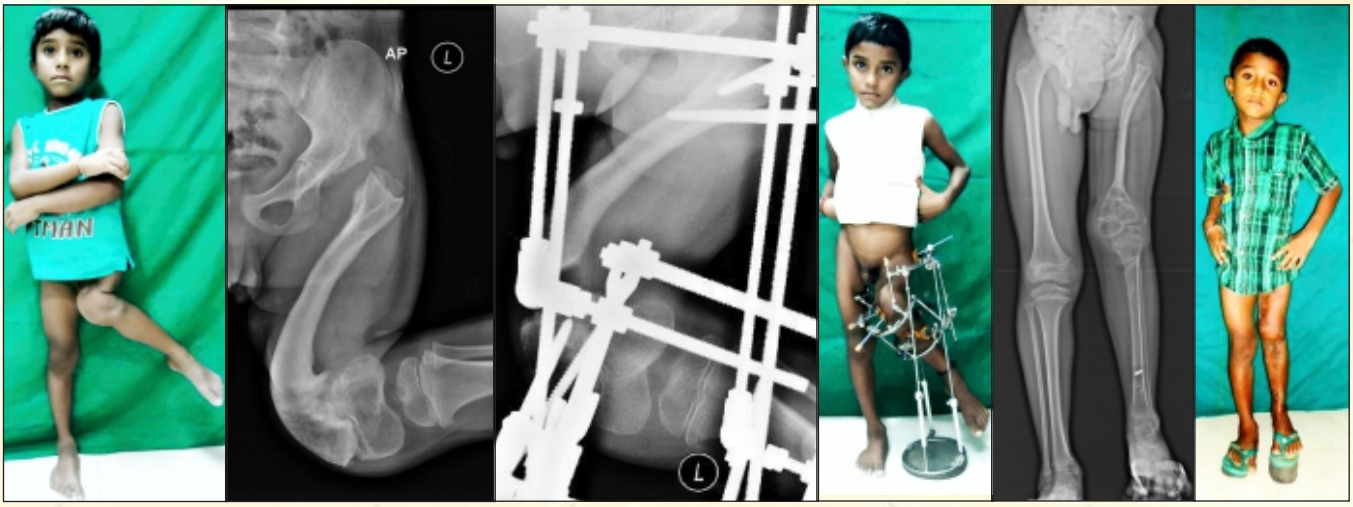
It is very surgeon friendly and the labour needed to change montages of the fixator to correct angular, rotational and translation deformities is eliminated.

Regardless of the advantages of 6-axis fixators, the fact remains that these remain external fixation devices and remain on the limb for long durations. Hence the 4trh generation of deformity correction consists of a hybrid of external fixation to motor and perform lengthening and deformity correction and Internal fixation devices like locked nails and plates to hold the length and corrected positions stably. This dramatically reduces external fixation time and can be used typically in older children and adolescents.

Severe Varus, Recurvatum, Internation Rotation and Shortening caused by childhood osteomyelitis. Corticotomy at apex of deformity and in order: length=7 cm, angulation, translation and rotations corrected. Each has a montage change. Rotation corrected last. Perfect lengths & alignment.

>60° Valgus at distal tibia due to ;growth arrest due to osteomyelitis. Ilizarov apparatus applied to tibia as well as foot. Supramalleolar osteotomy done. Gradual correction of valgus with Motor rods applied perpendicular to the direction of the deformed ankle mortise. Perfect correction.

Knee is fused in 90° flexion along with no shortening in a 14 yr old . Skin & soft tissues very poor over the knee and scarring in Popliteeal fossa. We need to straighten but keep ~ 5° flexion. This target achieved by performing osteotomy at Supracondylar level ; away from CORA(apex) and Hinges placed away from ACA on purpose to achieve Rule 3 deformity correction. Minimal anterior translation mimics a mild FFD which is a desirable position in an arthrodesed knee.



7 yr old with severe valgus > 90° with shortening. Destroyed hip as well., In first stage, a supracondylar osteotomy done to gradually correct and lengthen to a moderate extent to allow thin bone to form good regenerate. in 2nd stage he will get a Ilizarov Hip Reconstruction to give a pelvic ;support and stabilize the hip.

Shortening

Limb Shortening can reach dramatic proportions when caused by childhood osteomyelitis. We have treated shortening of as much as 23 and 26 cm in one stage in such patients. Arrest of the lower femoral, upper tibial and upper humeral growth plates leads to dramatic growth retardation and arrest.

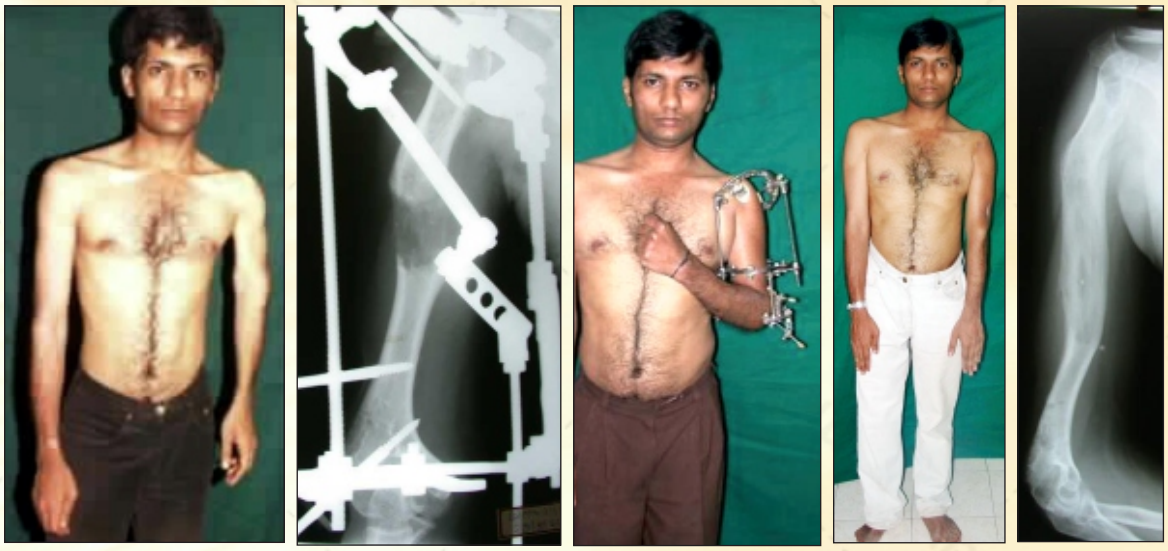
The use of specific hardware (whether Ilizarov or LRS or TSF fixator) is less important. There are some differences which need to be understood and behaviour of each device mastered. The important aspect is to understand and use the Seven Golden principles of Limb Lengthening very judiciously.

FigA1.

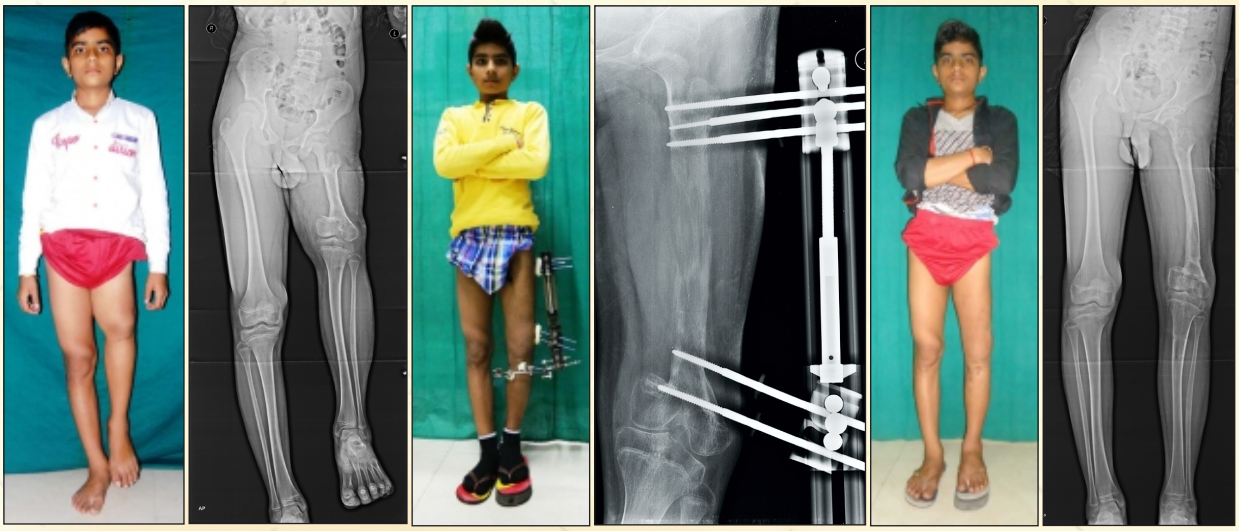
These are

1) Stable Fixation
2) Percutaneous low energy Corticotomy or osteotomy
3) No initial Gap or displacement at osteotomy
4) Latency period
5) Rate : usually no more than 1 mm per day
6) Rhythm of distraction: practically at a rate of ¼mm four times a day.
7) Preserved Vascularity and Function

The beauty of the Ilizarov principles is that it allows us to re-create a physis at any level in the bone. Given due respect to joint integrity and function it allows extensive lengthening that is usually required in the aftermath of childhood osteomyelitis.



11 cm shortening of Humerus due to childhood soteomyelitis. 19 yr old had a lengthening with Ilizarov and achieved the entire length along with preserved movements of elbow. Lengthening in osteomyelitis is least troublesome for Joint ROM.



10 yr od with dramatic shortening of femur. Treated with an LRS fixator for 14 cm length. 5 cm shortening persists which will be corrected in 2nd stage.