Adolescent with 15-cm Humeral Shortening from Osteomyelitis Treated by Humeral Lengthening via Circular External Fixation

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Abstract

Fifteen year old male with a multifocal osteomyelitis presumably due to neonatal sepsis resulted in varus deformity of the proximal tibia with internal rotation and shortening, which were corrected previously, and varus-procurvatum deformity of the left humerus with 15-cm shortening. Patient underwent 14-cm humeral lengthening after midshaft osteotomy and acute deformity correction using circular external fixation.

1 Brief Clinical History

The patient is a 15 year old male known to have multifocal septic arthritis as an infant with resultant joint disruption and physeal growth disturbance of the knee, proximal tibia, shoulder, and proximal humerus, all on the left (Fig. 1). Previously, he had undergone tibial angular deformity correction and lengthening with an excellent clinical outcome. His current complaints include significant glenohumeral intra-articular shoulder pain, markedly reduced shoulder abduction (50°), and limited external/internal rotation (20°), with a cosmetically displeasing substantial shortening (15 cm) of the humerus (Figs. 2 and 3). He has limitation of ipsilateral elbow flexion to approximately 100°, which is asymptomatic. He is neurovascularly intact and in good general health.

2 Preoperative Clinical Photos and Radiographs

See Figs. 1, 2, and 3.

3 Preoperative Problem List

- Cosmetically displeasing 15-cm humeral shortening
- Asymptomatic 40° varus-procurvatum deformity of the affected humerus
- Glenohumeral post-septic degenerative arthritis with significant pain and very limited shoulder range of motion
- Limited elbow flexion to approximately 100°

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Fig. 1 Preoperative AP and LAT radiographs of the humerus demonstrating significant distortion of the glenohumeral joint and proximal humerus. Note varus-procurvatum deformity (40°) of the humeral diaphysis (asymptomatic) and the severe (15 cm) shortening

Fig. 2 Preoperative view from behind showing substantial shortening of the left humerus
4 Treatment Strategy

Because of the extreme shortening associated with angular deformity, circular external fixation was elected to effect humeral lengthening. The patient was carefully evaluated by upper extremity specialists before the surgery with respect to the glenohumeral pain and significant limitation of shoulder motion. In the context of the severity of the articular deformity, he was considered a candidate for shoulder arthrodesis. The patient was counseled that humeral lengthening would have no positive and, possibly, a detrimental effect on shoulder pain and range of motion (ROM). He elected humeral lengthening to correct the cosmetic deformity, knowing that shoulder arthrodesis could be performed subsequently if symptoms warranted. To preserve shoulder and elbow ROM and prevent potential joint subluxation, systematic exercises and periodic evaluation during the course of lengthening were included in the treatment strategy.

5 Basic Principles

Fixation strategy for long-distance humeral lengthening is based on hybrid bone fragment stabilization utilizing a combination of wires and half-pins proximally and cross wires only distally (Cattaneo et al. 1990, 1993; Lee et al. 2005; Pawar et al. 2013). This approach maximizes longevity of the interosseous fixation and dimensional flexibility in correction of existing deformity of the humerus as well as an opportunity to correct secondary deformities that could develop during lengthening. After frame application, a humeral osteotomy is carried out by multiple drill holes connected using a narrow osteotome just distal to the deltoid insertion after subperiosteal dissection through an anterior approach to the humerus. Humeral lengthening in pediatric patients is accomplished using standard Ilizarov protocol.
Regenerate bone tends to form well in the distraction gap during humeral lengthening, and the surgeon must monitor the new bone formation carefully, altering the rate of distraction as indicated. As a generality, patients undergoing upper extremity lengthening do not have as much pain or interference with mobility as those undergoing lower extremity lengthening. Activities of daily living, however, may be significantly impacted by the upper extremity fixator, and consultation with an occupation therapist is very helpful.

6 Images During Treatment

See Figs. 4, 5, 6, 7, 8, 9, 10, and 11.

7 Technical Pearls

Frame configuration and bone fixation pattern for humeral lengthening must be carefully selected to allow safe application of the device to a short and often deformed humerus without compromising stability of bone fragment fixation. Our standard fixation of the proximal humerus in those cases consists of two posterior-to-anterior 1.8-mm diameter olive crossing wires and one lateral 4-mm diameter half-pin inserted proximal to the deltid tubercle and attached to a semicircular external support (Fig. 4), which is shaped as a half ring with an elongated ends (e.g., Ilizarov “Omega” ring, TrueLok foot plate). Fixation of the distal humerus is usually achieved by three transverse 1.8-mm diameter wires including two cross olive wires located the most distally and one smooth drop wire positioned at some distance more proximally secured to a full and 5/8 ring block (Fig. 5). Following osteotomy, proximal and distal external
supports are interconnected by telescopic distraction rods allowing gradual lengthening. In cases when the
distance between the external supports does not allow for the shortest telescopic rods, we use regular
threaded rods and special TrueLok square nuts with attached concave washers (Fig. 7) that can be turned
together by a double wrench for gradual compression or distraction.

8 Outcome Clinical Photos and Radiographs

See Figs. 12, 13, and 14.
9 Avoiding and Managing Problems

The most important challenge of circular external fixation on the short and deformed humerus is providing sufficient stabilization of the bone fragments, while avoiding a peripheral nerve injury. Unfortunately, anatomical constraints and pathological changes in bone and soft tissue structure do not allow the application of the most rigid external support configuration such as full ring and limit the utilization of such parameters as maximum wire crossing angles and wire tension in achieving satisfactory bone fragment stabilization. Therefore, the addition of the lateral half-pin to two wires crossing at the very obtuse angle (15°–20°) or replacement of those two wires with two to three half-pins similar to proximal femoral fixation is employed for proximal humeral fixation. The use of posterior olive wires will also help in preventing anterior translation of the apparatus by the patient leaning on the back of the apparatus when reclined. Distally, the angle between the two crossing wires is even smaller (10°–15°), requiring addition of the drop wire to enhanced anterior/posterior bending stability. Sometimes, the length of the distal humeral

Fig. 7  Intraoperative photograph showing elbow ROM at the end of the surgery. Note sufficient opening on the distal external support anteriorly maximizing joint flexion
Fig. 8 Postoperative AP and LAT radiographs at 5 days of distraction. Note correlating inter-fragmentary gap and bone fragment orientation after acute deformity correction.

Fig. 9 Postoperative AP and LAT radiographs at 2 months of distraction. Note typical three-zonal distraction regenerate and maintenance of bone fragment orientation during the lengthening.
fragment is too short, thereby preventing the insertion of the drop wires. In those cases, two olive wires can be used, crossing each other at a larger angle in the coronal plane and attached to the external support using connection posts/cubes. To avoid nerve injury during wire/half-pin insertion and acute manipulation with bone fragments, somatosensory evoked potential (SSEP) monitoring of peripheral nerves is
Finally, the surgeon should have no hesitation in performing limited exposures of the bone and/or neurovascular structures during wire and half-pin placement if deemed appropriate.

Fig. 12 AP and LAT radiographs of the humerus 2 years after frame removal demonstrating excellent alignment, complete remodeling of the newly formed bone with reconstitution of the medullary canal, and no deterioration of the deformed humeral head.

Fig. 13 Back view photograph 2 years after frame removal. Note that humeral length is equal to the opposite side. Patient is skeletally mature. He complains of some moderate pain in the shoulder, related to cold weather.
Fig. 14  Lateral view photographs illustrating preserved elbow ROM (from full extension to 90° of flexion). Patient remains with restricted motion at the shoulder but totally satisfied with the outcome and not desiring of a shoulder fusion for symptoms at this time

10 Cross-References

- Humeral Deformity Secondary to Ollier disease - Angular Correction and Lengthening with a Taylor Spatial Frame
- Humeral Lengthening and Deformity Correction in Ollier’s Disease: Distraction Osteogenesis with a Multiaxial Correction Frame
- Humeral Lengthening for Septic Growth Arrest
- Humeral lengthening in Erb’s Palsy
- Humeral Lengthening with a Motorized Intramedullary Lengthening Nail
- Management of Humeral Deformity in Osteogenesis Imperfecta

References and Suggested Reading