Nail Fixation of Proximal Humerus Fractures

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ABSTRACT

Proximal humerus (PH) fractures are among the most fracture types. Surgery is indicated in displaced fractures. The charge-book for surgical management of PH fractures is restoring PH anatomy, obtaining stable osteosynthesis, and conserving PH vascularization. Proximal humerus nailing is an osteosynthesis technique we have been using since 2000. Our initial indication for using a nail for PH fractures was displaced fractures of the surgical neck in elderly patients; these have since been expanded to include 3-part fractures, some special proximal humeral fracture dislocations, and 4-part valgus impacted fractures. However, nail fixation for PH fracture is not a panacea, and our surgical arsenal also includes bone sutures, percutaneous osteosynthesis, anatomical PH plates, and PH fracture prostheses. We detail the technique and the indication for each case. This technique is technically demanding, but after a learning curve, nail fixation for PH fractures is a very good technique if the indication is well defined.

Keywords: osteosynthesis, shoulder fracture, nail, technique

Proximal humerus fractures (PHFs) classically lie above the pectoralis major tendon.

Surgery is indicated in displaced fractures, following Neer’s criteria, exceeding 1 cm of displacement and/or 45 degrees of rotation. In addition, the patient’s age, functional demands, and associated lesions and pathology must also be considered.

The charge-book for surgical management of PHFs is as follows:

–Restoring PH anatomy:
  1. Restoring a 130-degree cervicodiaphyseal angle, with particular care to avoid varus malalignment;
  2. Restoring humeral retroversion;
  3. Reducing the greater and lesser tuberosities to avoid impingement anteriorly and posteriorly with the glenoid, and subcoracoid and acromioclavicular impingement; and
  4. Restoring good bone contact at the surgical neck to decrease the risk of nonunion.

–Stable osteosynthesis to avoid secondary displacement and allow early rehabilitation.

–Conserving PH vascularization to avoid iatrogenic osteonecrosis of the humeral head.

Proximal humerus nailing is an osteosynthesis technique we have been using since 2000 with the Telegraph nail (FH Orthopedics, Heimsbrunn, France).

The Telegraph is a 150-mm straight anterograde nail available in 3 diameters (7, 8, and 9 mm), secured proximally with 3 locking screws (2 lateromedial and 1 anteroposterior) and distally with 2 (1 dynamic in an oblong hole and 1 static; Fig. 1).

According to Neer and the Association of osteosynthesis (AO) classification, our initial indication for using the Telegraph nail was displaced fractures of the surgical neck in elderly patients; these have since been expanded to include 3-part fractures, proximal humeral fracture dislocations, and 4-part valgus impacted fractures according to Duparc and Largier.
For proximal humeral osteosynthesis, the Telegraph nail is not a panacea; our surgical arsenal also includes:

- Solid, thick, nonresorbable bone sutures;
- 3.5-mm fully threaded cortical screws with washers;
- Percutaneous 20/10 mm diameter distally threaded pins (Coulisstop, FH Orthopedics);
- Anatomical PH plates with divergent locking epiphy seal screws (plaque LCP AO, Synthesis); and
- Proximal humerus fracture prostheses (Aequalis fracture, Tornier) or a reversed prosthesis.

We have stopped using elastic retrograde nailing in our practice.

The present article details our surgical technique according to each indication.

### PATIENT POSITIONING

The patient is placed in a beach-chair position with the trunk at 45 degrees to the plane of the floor (Fig. 2). The patient is positioned so that the operated shoulder protrudes slightly over the edge of the table with the

![FIGURE 1. The Telegraph nail.](image1)

![FIGURE 2. Patient positioning with the fluoroscope.](image2)

![FIGURE 3. Patient positioning with the arm draped.](image3)

![FIGURE 4. The extensile surgical approach.](image4)
medial border of the scapula supported by the table. The patient’s head is secured in a neutral position in reference to the trunk by adhesive tape.

The arch of the fluoroscope is positioned at the patient’s head, perpendicular to the arm axis, and inclined to provide an anteroposterior image of the shoulder, with the joint in a neutral position. The radiographic amplifier screen is placed on the contralateral side of the table near the patient’s feet.

Initial fracture reduction maneuvers are performed under fluoroscopic control before preparing and positioning the operating drapes. A profile view is obtained by rotating the amplifier 90 degrees and abducting the humerus.

The entire extremity is prepared and draped within the operative field so that it may be manipulated during the operation. The fluoroscope is protected with a sterile drape (Fig. 3).

**PROXIMAL HUMERAL SURGICAL NECK FRACTURE OSTEOSYNTHESIS TECHNIQUE**

Normal humeral diaphyseal displacement with respect to the epiphysis is internal translation caused by the pectoralis major, latissimus dorsi, and teres major muscles. The epiphysis rotates backward and in varus.

Fracture reduction is performed before placing the operating drapes. Longitudinal traction is applied in the humeral axis with the elbow flexed. Lateral and posterior pressure is applied by the surgeon with his hand on the proximal humeral diaphysis. An assistant can hold the epiphysis in position if the shoulder is not too large. Reduction is then performed progressively under frontal and lateral fluoroscopic control. The axillary profile view is obtained by swinging the radiographic amplifier through 90 degrees and abducting the humerus while maintaining reduction. If the reduction obtained with the external maneuvers is satisfactory, a minimally invasive percutaneous technique may be performed; if not, an extensile approach will be required (Fig. 4).
The minimally invasive approach involves a 2- to 3-cm anterolateral incision starting at the anterolateral acromial angle following the direction of the deltoid fibers. The length of the incision can be modified according to surgeon experience and patient morphology. The deltoid fibers are split to access the subacromial bursa that we excise to visualize the supraspinatus tendon. The arm is held in the plane of the body, which keeps the anterior two thirds of the humeral head anterior to the acromial arch. The direction of the supraspinatus tendon fibers must be visualized, and the anterior and posterior extent of the humeral head is identified using a blunt instrument such as dissection scissors. A 2- to 3-cm incision is made in the supraspinatus tendon from lateral to medial starting at the greater tuberosity. The hematoma is evacuated, and the joint cavity is irrigated to obtain a clear view of the joint surface. Two stay sutures are then placed on either side (ie, anterior and posterior) of the tendon incision and held with clamps to expose the joint surface below. Other retractors are withdrawn once the articular surface is visible. The stay sutures should be of adequate length for the clamps to be outside the fluoroscopic field, not impairing humeral head visualization. The humeral head is then pierced with a square awl to create the nail entry hole. In the frontal plane, the entry point should be at the summit of the humeral head, 0.5 to 1.0 cm from its lateral edge and completely surrounded by cartilage.
Sagittally, the entry point should be in the center of the humeral epiphysis or slightly anterior with respect to the cartilaginous surface. The point is checked on the radiograph, and the awl is inserted through the head to the level of the fracture (Fig. 5). Rotator cuff ruptures may be found in elderly patients, and in these cases, a tenotomy of the long head of the biceps tendon may be performed with resection of the articular portion. The square awl is then removed, and a reduction maneuver is performed followed by the introduction of a 7-cm reamer on an American handle. The reamer is inserted into the head, across the fracture line, and into the humeral diaphysis. It is impossible to abduct the arm for an axillary profile radiograph with the reamer inserted. Small movements of the distal humeral diaphysis and the fluoroscope are required to ensure that the reamer threads properly into the diaphysis as it crosses the fracture site. Adequate reduction between the humeral head and diaphyseal fragments may be confirmed by mobilizing the humerus after the reamer is well positioned within the diaphysis. Depending on the bone quality and size of the medullary canal, size 8 and 9 reamers are progressively introduced. Fracture reduction is improved with a tight diaphyseal fit; therefore, the largest nail possible should be used. When the largest-diameter reamer has been introduced, a standard 150-mm humeral nail of the same diameter is secured onto the insertion handle that allows for locking screw targeting. While maintaining fracture reduction, the nail is inserted distally through the entry hole until its proximal extent is 0.5 cm below the surface of the humeral cartilage. The intramedullary position of the nail is checked by mobilizing the arm and confirmed fluoroscopically in the frontal plane only. Proximal locking may now be completed. With the mini open approach, locking screws are inserted percutaneously, whereas a larger open approach may allow proximal locking screw insertion through the skin incision. Locking screw possibilities include 2 lateromedial and 1 anteroposterior screw holes. The 2 lateromedial screws are inserted under fluoroscopic control. Two screws are generally sufficient, however, in cases of elderly patients with very porotic bone, the third anteroposterior proximal screw may be necessary (Fig. 6). Distal locking is then performed percutaneously using the ancillary guide. During distal-locking screw insertion, the forearm must be maintained in neutral rotation to avoid malrotation through the fracture site. The nail is locked distally through the oblong hole to achieve dynamic impaction of the fracture postoperatively. The insertion handle is removed, and positioning is checked both under direct vision and under frontal and lateral fluoroscopic control. Wound closure begins with suturing the supraspinatus using interrupted FIGURE 10. The 2-part fracture.

FIGURE 11. The 2-part fracture reduced and fixed.
side-to-side resorbable stitches. A postoperative drain is not necessary.

An extensile surgical approach (Fig. 4) is necessary if the fracture is not amenable to the closed reduction techniques. Similar to the mini open approach, an incision is made in the supraspinatus in line with its fibers and stay sutures are placed on either side. The stay sutures are useful for visualization and traction, allowing progressive reduction of varus displacement and posterior shift of the humeral head (Fig. 7). If this, combined with the external maneuvers, fails to achieve satisfactory reduction of the head on the diaphysis, the square awl or the first reamer can be introduced into the humeral head for leverage to align the fragments (Fig. 8). A medial approach and proper insertion angle for the awl and various reamers are facilitated by incising the deltoid up to the anterolateral angle of the acromion and possibly continuing proximally onto the acromion if necessary.

- **OSTEOSYNTHESIS OF 3-PART PROXIMAL HUMERAL FRACTURES**

We have extended the indications for humeral nailing to include more complex 3-part fractures, with an original technique combining bone suture and Telegraph nail osteosynthesis.

The principle is to reduce the total number of fracture fragments before inserting the humeral nail. An anatomical reconstruction of the proximal humeral epiphysis (ie, the humeral head and tuberosities) is completed and stabilized using simple nonabsorbable bone sutures. The complex 3-part fracture is thus simplified into a 2-part surgical neck fracture, which can be reduced and stabilized with a humeral nail. The proximal locking screws of the Telegraph nail also increase the stability of the epiphyseal synthesis (Fig. 9).

![FIGURE 12. The 3-part fracture reduced with osteosutures and the nail.](image1)

![FIGURE 13. The 4-part valgus impacted after reduction.](image2)
The humeral head should be reduced gently with minimal trauma. Stabilization with a temporary cephaloglenoid arthrodesis pin is rarely needed but helpful in difficult cases. The tuberosities are then reduced, and bone clamps are used to maintain the reduction while bone sutures are passed. The intertubercular fracture line usually lies outside the bicipital groove, and generally, there is enough room for 3 or 4 cross-bone sutures without infringing on the bicipital groove. The intraosseous suture hole locations are marked in pairs using the tip of an electrocautery instrument on either side of the fracture line. The intertubercular bone clamps are removed, the suture holes are drilled 2 mm apart along the fracture line, and heavy braided nonabsorbable sutures are threaded through. Each suture is threaded through 2 holes at the same latitude. Fracture reduction is repeated and maintained using the bone forceps while the sutures are tied.

Once the epiphysis has been reconstructed, Telegraph nail osteosynthesis follows using the procedure described previously for subtubercular fractures. Reaming should be done carefully using only a 7-mm reamer. A 7-mm nail is gently introduced and pushed distally to the correct depth. In our experience, 7-mm reaming and nailing has not damaged the epiphyseal osteosynthesis.
Locking-screw insertion begins proximally, and the epiphyseal osteosynthesis is completed with the 3 epiphyseal screws.

An alternative to the previously described technique consists of first stabilizing the epiphysis, consisting of only the humeral head and lesser tuberosity onto the humeral diaphysis. The nail position is checked visually and under fluoroscopic control, and then locked distally, either dynamically through the oblong hole or statically depending on the degree of comminution and osteoporosis. Both distal locking screws may be used if necessary. The greater tuberosity fragment is then reduced and se-

**FIGURE 17.** Cephalo-metapyleal anterior fracture dislocation (CT-scan).

**FIGURE 18.** Cephalo-metapyleal anterior fracture dislocation reduced and fixed.

**FIGURE 19.** The 4-part valgus impacted fracture.

**FIGURE 20.** Reduction manuever for 4-part valgus impacted fracture.
clamps to manipulate the tuberosity, it is reduced onto the epiphysis and held secure for radiographic evaluation. A complication risk at this point is overreduction of the greater tuberosity by positioning it too distally. The tuberosity is stabilized using the nail insertion handle, which is still in place, to position the 2 proximal locking screws. Supplementary bone sutures may be used if necessary.

**OSTEOSYNTHESIS IN FRACTURE DISLOCATION**

Sometimes, anterior or posterior fracture dislocation is the final stage of a humeral notch, characterized by a metaphyseal spur connected to the humerus head. The spur acts as a vessel-carrying blade, with very little risk of necrosis. Duparc and Largier\(^3\) describe them as cephalometaphyseal fracture dislocation (Figs. 10 and 11).

We have used the Telegraph nail on several occasions to stabilize these fractures. A transdeltoid approach provides satisfactory visualization of the fracture site. Reducing the humeral head can be difficult if displacement is considerable and if there is a large Hill-Sachs or reverse Hill-Sachs lesion (depending on the direction of dislocation). Reduction is achieved gradually and with minimal trauma using a blunt instrument. The reduction of the humeral head fragment remains very unstable until the tuberosities have been reduced; here, temporary stabilization of the head may be maintained by a large Steimann pin. The pin is introduced percutaneously in a posterior or anterior position for posterior or anterior dislocation, respectively. The tuberosities are then reduced and secured using intraosseous sutures as described previously. Once the tuberosities have been reduced and fixed and the humeral head is stable with the glenohumeral joint reduced, the Steinmann pin is no longer required. The complex fracture dislocation, now simplified to a 2-part surgical neck fracture, is fixed using a Telegraph nail (Fig. 12). As stated previously, the epiphyseal locking screws increase stability of the reconstructed humeral head.

**OSTEOSYNTHESIS IN 4-PART VALGUS IMPACTED FRACTURES**

In the group of 4-part type fractures according to Neer’s classification,\(^1\) 4-part valgus impacted fractures were
characterized by Duparc and Largier and studied by many authors. Humeral head impaction caused by traumatic axial compression under the acromial arch results in valgus displacement with impaction of the articular surface. The cervicodiaphyseal angle is increased, often to more than 150 degrees. The greater tuberosity is fractured and displaced relative to the articular surface. In contrast to other displaced fractures, periosteal attachments often remain between the greater tuberosity and the diaphysis. The lesser tuberosity is often fractured but usually nondisplaced or minimally displaced relative to the head fragment, however, it may present internally translated (Fig. 13). The internal connection between the head and the humeral diaphysis may be conserved or may be broken. The risk of humeral head necrosis is moderate in these 4-part fractures, and osteosynthesis is indicated, especially in young patients. The standard anterolateral approach is used, and its extent is determined by the ability to visualize the various fracture fragments to ensure satisfactory reduction before introducing the nail. The periosteal attachments between the greater tuberosity and the humeral diaphysis must be conserved. The humeral head is approached via a supraspinatus tendon incision and, in case of displacement, also via the fracture line between the greater and lesser tuberosities; this portal should only be used without worsening the fracture. The hematoma must be evacuated and the fracture site thoroughly irrigated to provide a good view of the rotated (commonly horizontal relative to the diaphysis) cartilage surface. Using a periosteotome or a large pin, the humeral head is reduced, restoring the 130-degree cervicodiaphyseal angle. It is important to mobilize the head fragment with a large amount of subchondral bone and to conserve the internal epiphyseal-diaphyseal connection if it is intact. Reduction is obtained by elevating the articular fragment combined with adduction of the humerus if necessary (Fig. 14). The 130-degree cervicodiaphyseal angle reduction criterion is checked on the radiograph. The proximal entry hole is then made in the summit of the humeral head. Canal preparation must be performed carefully to conserve the external osteocartilaginous bridge, and the smallest (7 mm) reamer is recommended. The subtubercular fracture site is catheterized, the nail is positioned (Fig. 15), and static distal locking is performed. The secured nail holds the head properly reduced, acting as a prop. Greater tuberosity reduction must then be assessed—but this is usually straightforward as the humeral head is displaced by the fracture with no relative movement between the greater tuberosity and diaphysis. The greater tuberosity is stabilized by 2 proximal locking screws, completing humeral head reduction (we do not usually perform bone grafting during this procedure for these fractures). The lesser tuberosity reduction is then checked and, if unsatisfactory, completed by traction sutures and bone clamps. In this kind of fracture, the lesser tuberosity is systematically stabilized using the anteroposterior locking screw. If stability is unsatisfactory, greater and lesser tuberosity osteosynthesis may be augmented with other isolated screws, independent of the nail, or with bone sutures. In valgus impacted fractures, the ball-and-socket technique, involving first positioning and distally locking the nail within the humeral diaphysis followed by reduction and locking of the humeral head, is not recommended as it entails a serious risk of humeral head medialization and rupture of the internal epiphyseal-diaphyseal connection when present. Moreover, inserting a locking screw through the humeral head before positioning the greater tuberosity means that the screw will be buried within the bone. Subsequent screw and nail removal, if necessary, will result in serious iatrogenic bony damage.

**OUR INDICATIONS**

Intramedullary nailing is our treatment of choice for subtubercular surgical neck fractures in elderly subjects (Figs. 16–18). In younger patients, when external maneuvers achieve reduction, we use percutaneous 20/10 distally threaded pins, following the technique of Jaberg.
et al.,

using 2 anteroexternal and 1 anterior retrograde pin. When external maneuvers fail to achieve reduction or in the case of metaphyseal anterolateral comminution, precluding the insertion of retrograde pins, we use the nailing technique described previously.

The Telegraph nail is our technique of choice in 3-part fractures involving the surgical neck and greater tuberosity in elderly patients (Figs. 19 and 20). In younger subjects without osteoporosis or significant metaphyseal comminution, we prefer a percutaneous or minimally invasive approach of reducing the subtubercular fracture by external maneuvers and stabilizing the epiphysis and diaphysis using 2 threaded retrograde pins placed through the anterolateral cortex as described by Jaberg et al. The greater tuberosity fragment is then secured either percutaneously using cannulated screws when external maneuvers have achieved a satisfactory reduction or by a minimally invasive anterolateral approach to facilitate reduction and insertion of 4.5-mm cannulated or cortical screws, with or without washers.

We have stopped using elastic retrograde nail fixation in these cases.

In young patients, the reduction of fracture dislocations is initially attempted with external reduction maneuvers or relatively nonaggressive percutaneous instruments. When reduction is possible, stable fracture fixation using percutaneous pinning is preferred. In elderly subjects with fracture dislocations, shoulder prostheses are indicated and are our treatment of choice. If the tuberosity bone quality and rotator cuff tendons are satisfactory, a fracture prosthesis with tuberosity reconstruction and intraosseous sutures are preferred. In cases where the tuberosity fragments are insufficient, common in our very elderly patients, a reversed prosthesis is selected.

In young patients with valgus impacted fractures and nonporotic bone, we recommend using minimally invasive retrograde pins and securing the greater and lesser tuberosities with percutaneous or minimally invasive screws as described by Jaberg et al. The Telegraph nail is ideally suited for patients with poor bone quality or if metaphyseodiaphyseal comminution hinders satisfactory positioning of retrograde osteosynthesis pins (Figs. 21–24). In very elderly subjects with osteoporotic bone, a prosthesis may be implanted—in our practice, a reversed prosthesis is the treatment of choice.

**DISCUSSION**

The primary advantage of this nail is the locking epiphysyal screws that allow stable fixation in osteoporotic bone. The Telegraph nail is straight and is introduced directly into the cartilaginous area of the humeral head. The resulting cartilage lesion does not impair joint mobility, as it enters the glenohumeral articulation only at the very maximum of glenohumeral abduction. Crutch-type nails are inserted more laterally on the greater tuberosity, requiring iatrogenic injury to the rotator-cuff insertion.

Using a subacromial space approach for PHF osteosynthesis incontestably increases postoperative healing time and requires prolonged rehabilitation to restore complete mobility. If the nail is well positioned and does not protrude superiorly, the passage provided by a supraspinatus tendon incision of less than 1 cm, respecting the fiber axis, will not harm the rotator cuff. During the rare case of removal of a nail, we have found that the supraspinatus tendon incision perfectly healed. Nail removal should be avoided unless absolutely necessary, as extraction is more difficult technically and more damaging for the shoulder than implantation. Extraction requires a substantial rotator-cuff incision to visualize the humeral head and often a large bony window to access the proximal end of the nail. When removing a Telegraph nail, the insertion handle and accessory devices should be used to locate the locking screws, which may be concealed within in the tuberosities; failure to use these tools may result in needless bony exploration and iatrogenic injury.

In conclusion, nail fixation for PHFs is a very good technique if the indication is well defined. However, this technique is very technically demanding, and we conserve other technique for different indications.

**REFERENCES**


