Anatomic Shoulder Arthroplasty for Fracture: Indications and Technique

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Filippo Castoldi, Andrea Cimino, and Raffaele Garofalo

9.1 Introduction

Hemiarthroplasty is the procedure of choice for certain 3- and 4-part fractures, fracture-dislocations, and head-splitting fractures of the proximal humerus. It is a difficult procedure that requires experience in trauma and joint replacement surgery. The main difficulties arise from the management of the tuberosities and restoring of the correct version and length. The results are highly variable and sometimes unpredictable, related to effective pain control and restoration of normal function [1].

In particular, the main difficulty is the proper healing of the tuberosities which can be reabsorbed due to the poor quality of the bone and vascularization or migration and healing in an incorrect place.

F. Castoldi
Department of Orthopaedics and Traumatology, 2nd University Clinic, CTO Hospital Turin, Largo Turati 62, Turin 10128, Italy
e-mail: filippo.castoldi@unito.it

A. Cimino (✉) • R. Garofalo
Department of Orthopaedics and Traumatology, Mauriziano-Umberto I Hospital, Largo Turati 62, Turin 10128, Italy
e-mail: andreacimino87@gmail.com

9.2 Indications and Preoperative Planning

As already described in the chapter regarding the understanding of the fracture, one of the treatment cornerstones is the correct indication. This comes from the overall understanding of the type of both fracture and patient that we have to deal with concerning age, functional requirements, compliance, dominant side, and quality of the tissues [2–4].

9.2.1 Age

The age of the patient plays a vital role in our decision to treat. The patient under the age of 60 with high expectations is the ideal candidate for a hemiarthroplasty. This consideration should be made also on the basis of his ability to follow a demanding rehabilitation protocol completely different from that required when a reverse prosthesis is implanted.

Between 60s and 70s, the decision is related to the biologic age of the patient, to his general health, and to the presence of functional disorders prior to the trauma.

Above the age of 70, the patient's characteristics and the quality of the bone would be often in favor of the placement of a reverse prosthesis.

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9.2.2 Bone Quality

The quality of the bone affects (all) procedures: a poor quality of the bone with comminution of the tuberosity and a thin cortical can make the procedure extremely complex. The bone quality can be evaluated with standard X-ray picture and CT scan, but definitive assessment is still intraoperative. Therefore, it is recommended to have many different solutions available in the operating theater before operation, to solve any problem identified during the procedure [5].

9.2.3 Fracture Pattern

Three- and four-part fractures, fracture-dislocations, head-splitting fractures of the proximal humerus, impacted fractures of the humeral head with involvement of more than 50 % of the articular surface, and a very unstable calcar are the most frequent injury patterns we have to deal with. For details we refer to the chapter "Understanding the Fracture."

9.2.4 Rotator Cuff

The rotator cuff integrity can be assessed only intraoperatively. You can have an idea of the cuff condition, prior to surgery, inquiring the shoulder level of functional impairment before the injury and knowing that CT image that can sometimes highlight an atrophy of the rotator muscles.

9.2.5 Surgeon Experience

The surgeon experience plays an important role. As previously said, implanting a prosthesis in case of proximal humerus fracture is a complex procedure requiring extensive knowledge of technical and anatomic details.

Our specific relative indications for hemiarthroplasty in proximal humerus fracture are as follows:

- Age <70
- Fracture pattern: 3- and 4-part fractures, fracture-dislocations, head-splitting fractures of the proximal humerus, head ischemia based on Hertel criteria
- Good bone quality
- Non-comminuted tuberosities
- Patient with good compliance
- No cuff deficiency

9.2.6 X-rays

An AP view and an axillary view are mandatory. A CT is needed to better understand the nature of the fracture fragments, to identify their management and reduction, and also to have a perfect view of the glenoid.

9.3 Surgical Technique

9.3.1 Positioning/Exposure

The patient is placed in a beach-chair position on the edge of the operating table, taking care of leg position. The whole scapula must be visible and the arm must be freely movable.

The deltopectoral is the best approach for this surgical procedure. The skin incision goes straight from the lateral edge of the coracoid to the insertion of the deltoid muscle, paralleling the cephalic vein. You need to retract the pectoralis major medially and the deltoid laterally, splitting the two muscles apart (Fig. 9.1).

The subcutaneous tissues are divided and the deltopectoral interval is entered; the cephalic vein may be retracted either medially or laterally. Sometimes it could be difficult to identify the deltopectoral groove because of hematoma or poor quality of the muscles. It is easier to find the groove between the deltoid and the pectoralis, proximally near the clavicle where there is a natural fat space.

Bursectomy is often an important step: hematoma and bursa must be removed to gain a good view of the fracture anatomy.

It is necessary to identify the superior margin of the pectoralis major, which is an important anatomic landmark in verifying the height of the future implant, to correctly access the surgical site (Fig. 9.2). The clavipectoral fascia is opened

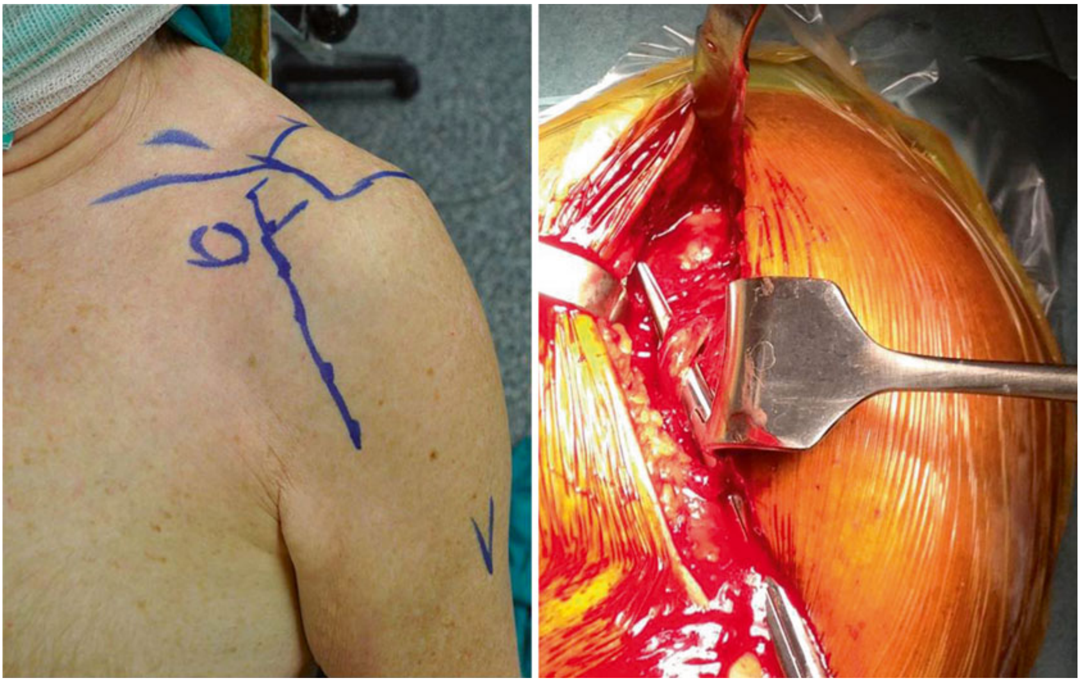

Fig. 9.1 Deltopectoral approach. Main landmarks: coracoid process, acromion, and distal deltoid insertion. Vision from this approach is optimal

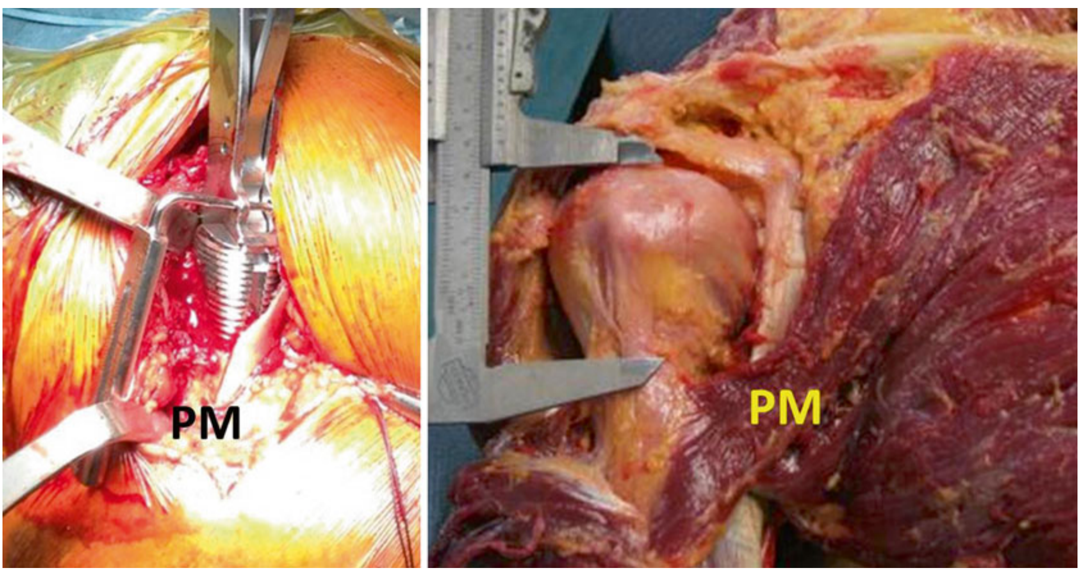

Fig. 9.2 It is very important to identify the top margin of the pectoralis major muscle (*PM*) that allows to define the height of the implant. To the left there is a ruler that measures the height of the rasp in relation to the tendon

and a self-retaining retractor is placed between the conjoined tendon and deltoid. It is easy to identify the long head of the biceps that is an excellent landmark to find the interval between the tuberosities. Tenotomy is performed (Fig. 9.3). The arm is then placed into abduction and internal rotation, and the greater and lesser tuberosities are identified. It is essential to

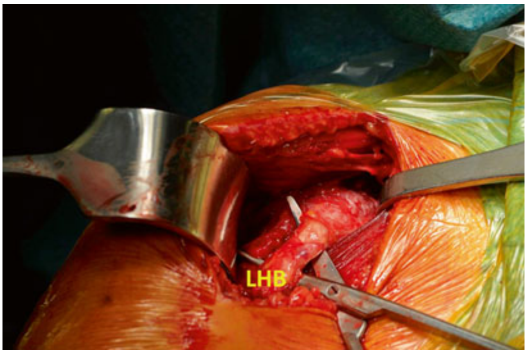

Fig. 9.3 Identify the tendon of the long head of the biceps (*LHB*). Frequently you perform a tenotomy

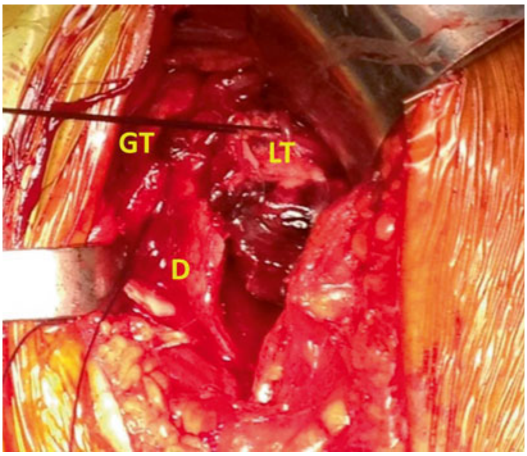

Fig. 9.4 Two no. 2 nonabsorbable sutures are placed in Mason-Allen-type stitches at the bone-tendon junction through the subscapularis and infraspinatus in order to manage the tuberosities (*GT* greater tuberosities, *LT* lesser tuberosities, *D* diaphysis)

preserve them with all the bone. Two no. 2 nonabsorbable sutures are placed in Mason-Allen-type stitches at the bone-tendon junction through the subscapularis and infraspinatus in order to manage the tuberosities (Fig. 9.4). It is helpful to release both tendons (subscapularis, infraspinatus) to obtain free fragments that can be easily placed around the implant.

The rotator interval is opened till the glenoid to release the coracohumeral ligament to expose the humeral head and the glenoid.

With the tuberosities retracted, the head fragment is removed; in order to measure the head size, it should be better to remove it in one piece (Fig. 9.5).

At this point the inspection of the glenoid can be easily done in order to assess its integrity and the good condition of the cartilage.

9.3.2 Humeral Preparation

The arm is left along the trunk and externally rotated, and the humeral shaft is exposed.

Since the metaphysis is typically "absent" due to the fracture, the humeral shaft is prepared with hand reamers until there is a gentle cortical resistance. A humeral trial is then placed. During this step, the surgeon must check carefully the fit of the diaphysis and the version and the depth of the implant. The fit is obtained evaluating the relationship between the stem and the canal; the retroversion is identified with anatomic references according to the used system (the alignment rod into the appropriate retroversion hole, referring to the forearm and to the condyles) (Fig. 9.6); the appropriate depth of the implant is measured referring to anatomic landmarks: the calcar and the distance between the tip of the humeral head and the upper margin of the pectoralis major [5.5 cm; (Fig. 9.7)].

It is important to measure the resected humeral head to decide the correct size (diameter and height) of the implant. In order to decide which size is best, it is important to remember that undersizing the head avoids the overstuffing that might lead to complications such as glenoiditis and tendon impingement (Fig. 9.8). The selected humeral trial head is placed.

You need to mobilize the tuberosities in order to approximate them around the prosthesis and the humeral shaft: the primary goal is the maximum contact between stem and shaft to restore their anatomic position (Fig. 9.9). The V-shaped fracture in the diaphysis represents a very important landmark for the reduction of the greater tuberosity (Fig. 9.10) [6]. The initial reduction of the greater tuberosity allows testing of both height and retroversion of the implant. With the tuberosities reduced, it is possible to define the

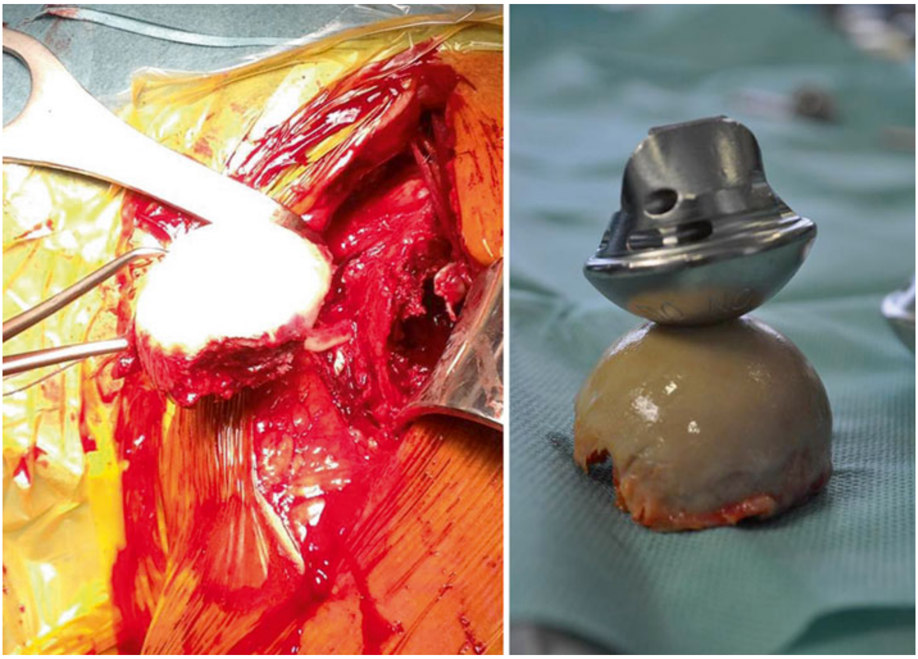

Fig. 9.5 Removal of the head if possible in one piece to allow a correct measurement

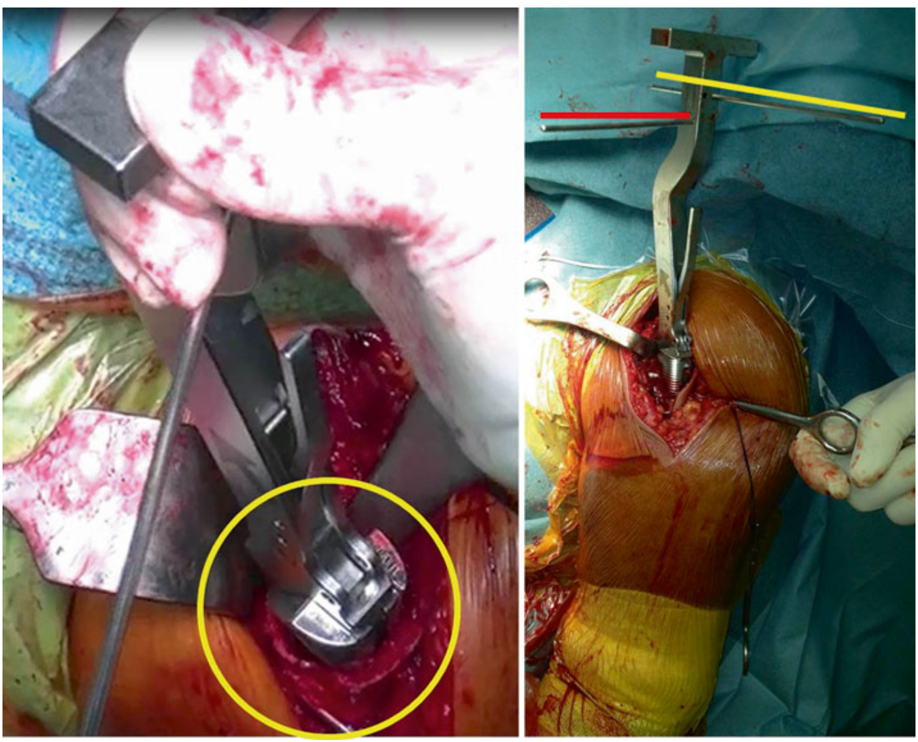

Fig. 9.6 *Left:* evaluation of the (*yellow circle*) refers to the filling of the rasp in the diaphysis. *Right*: evaluation of the orientation of the stem with the alignment rod: transepicondylar axis, *yellow*; forearm axis, *red*

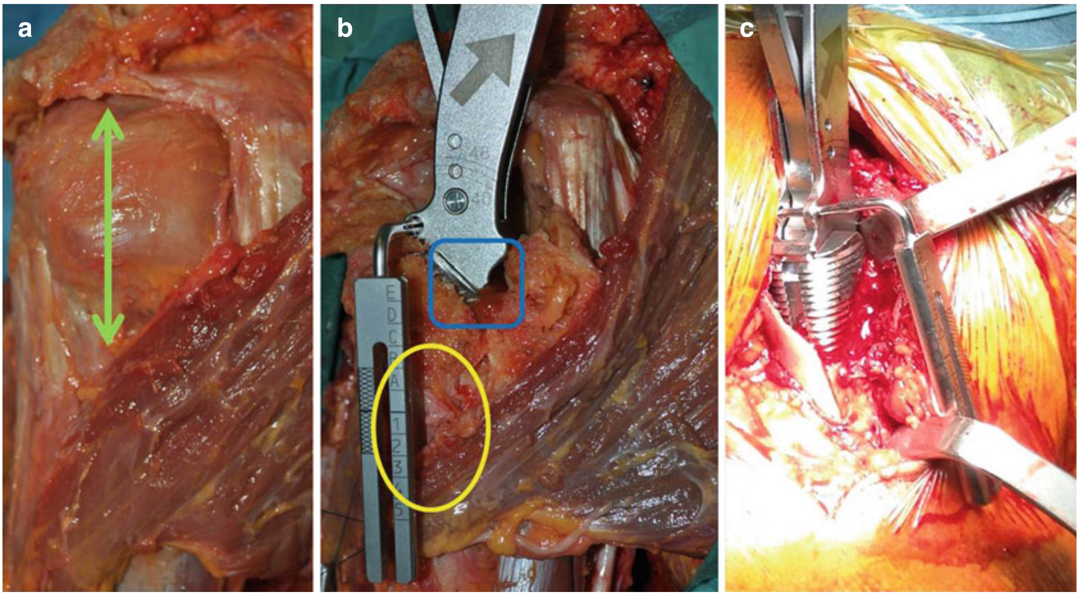

Fig. 9.7 (**a**) The distance between the tip of the humeral head and the upper border of the pectoralis major (*green arrows*). (**b**) The appropriate depth of the implant is measured referring to anatomic landmarks: the calcar (*blue circle*) and the distance between the tip of the humeral head and the upper margin of the pectoralis major (5.5 cm) (*yellow circle*). (**c**) The same ruler intraoperatively

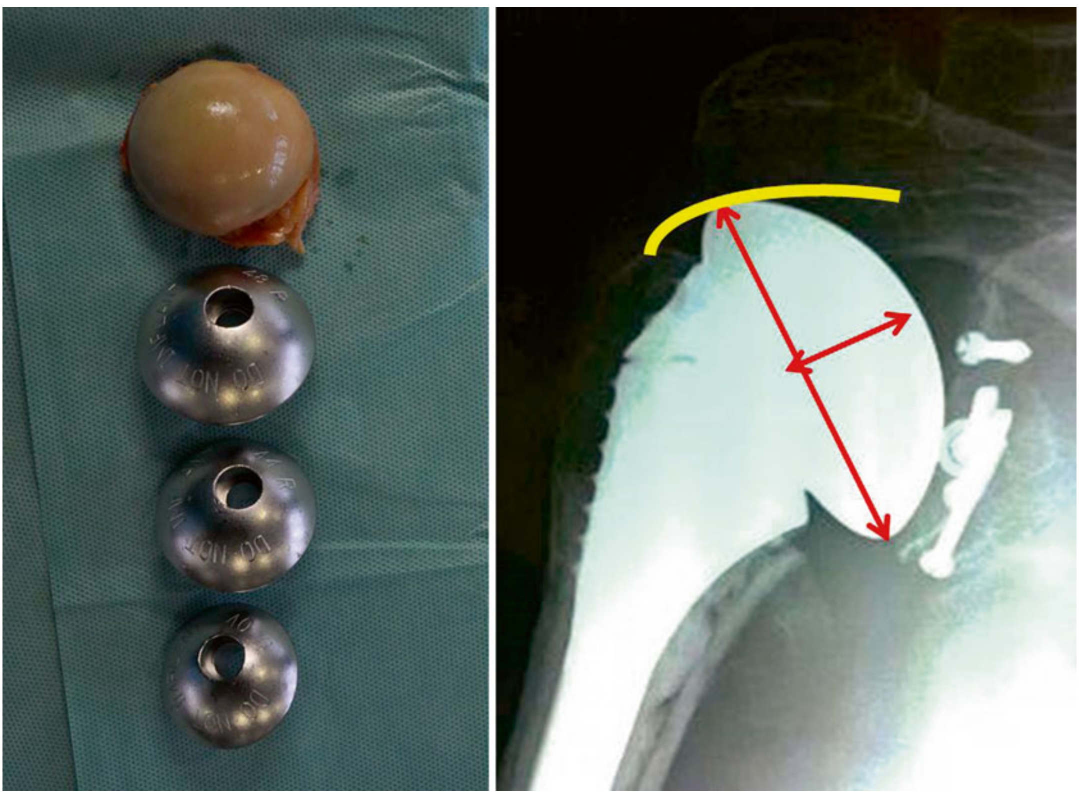

Fig. 9.8 Measurement of the humeral head: undersizing the head. *Right*: *yellow* tendon impingement of a humeral head oversized. *red arrows*: size(diameter and hight)

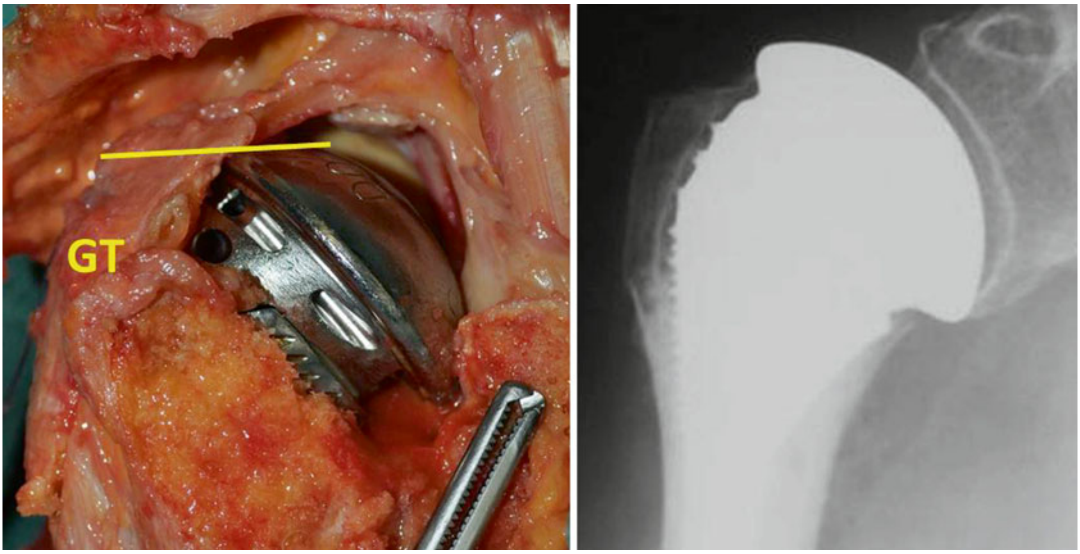

Fig. 9.9 *Left*: *yellow line* refers to level of gt and contact with the implant (*GT*). *Right*: post-op X-ray control demonstrating the perfect restoration of the anatomy

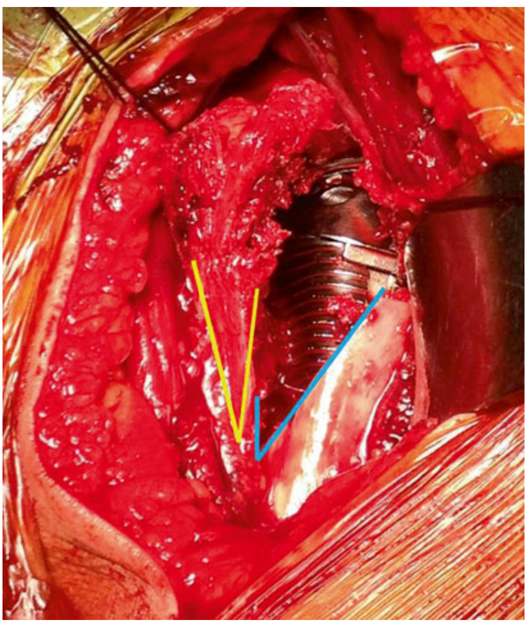

Fig. 9.10 The V-shaped fracture in the diaphysis (*blue line*) represents a very important landmark for the reduction of the greater tuberosity (*yellow line*)

correct position of the sutures that are supposed to anchor the tuberosities to the diaphysis and drill the holes for passing them (Fig. 9.11). The sutures must close the fragments around the implant stabilizing them and neutralizing the traction forces of the tendons (Fig. 9.12).

This calibration phase of the tuberosity reduction represents the key moment of the procedure: it may take time and it has to be done very precisely (Fig. 9.13) [7].

There is no known suture system that guarantees a reliable suture and an appropriate stability of the tuberosity: we consider of great importance the positioning of four circular sutures that span the two tuberosities and of two sutures anchored to the shaft that can neutralize the tension of the tendons.

Usually a conflict between the supraspinatus tendon and the prosthetic head and an incorrect reduction of the tuberosities can compromise their healing and the functional recovery of the shoulder.

A cement restrictor is then placed and the humeral canal cleaned and dried with pulsatile lavage. The cementation is performed with the definitive implant: it is essential to remove all the cement from the metaphyseal region and between the tuberosities. The height and the direction of the prosthesis are set as previously noted.

After all sutures are tied, trial motion is tested to ensure stable fixation of the tuberosities to the shaft (no movements are allowed between all the structures) and to rule out any abnormal

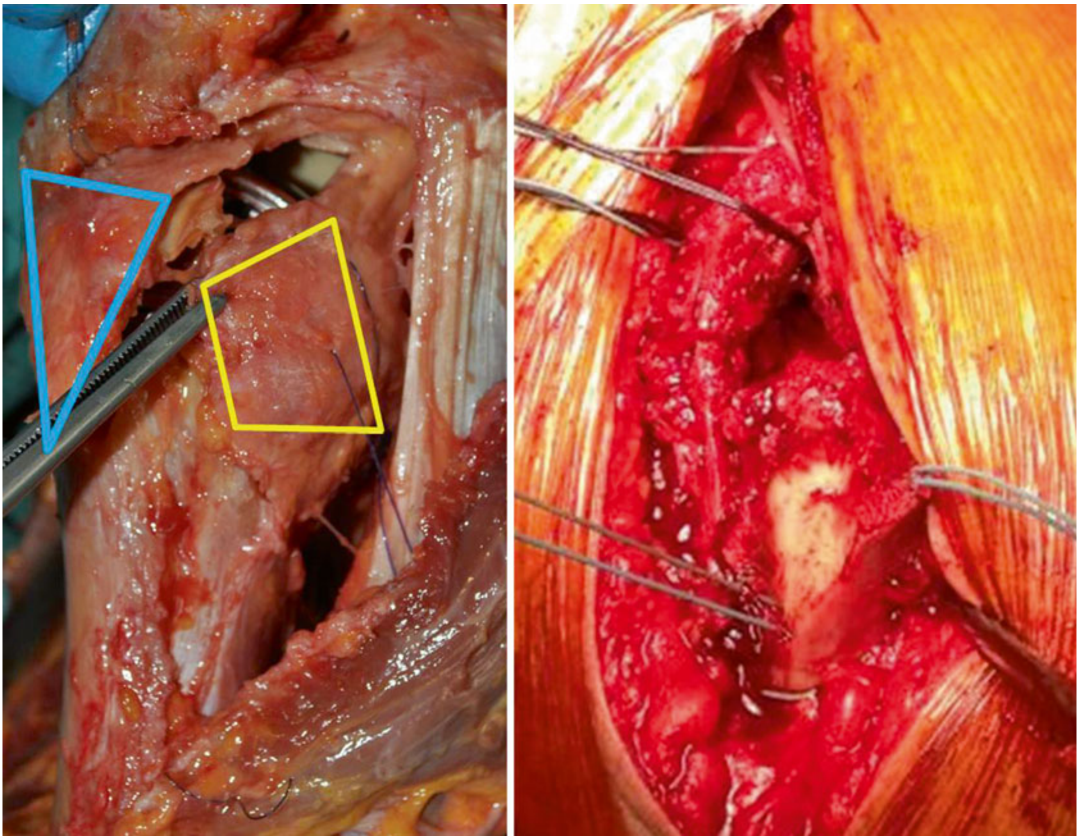

Fig. 9.11 With the greater (*blue*) and lesser (*yellow*) tuberosities reduced, it is possible to define the correct position of the sutures anchoring the tuberosities to the diaphysis and drill the holes for passing them. *Right*: sutures passing the diaphysis

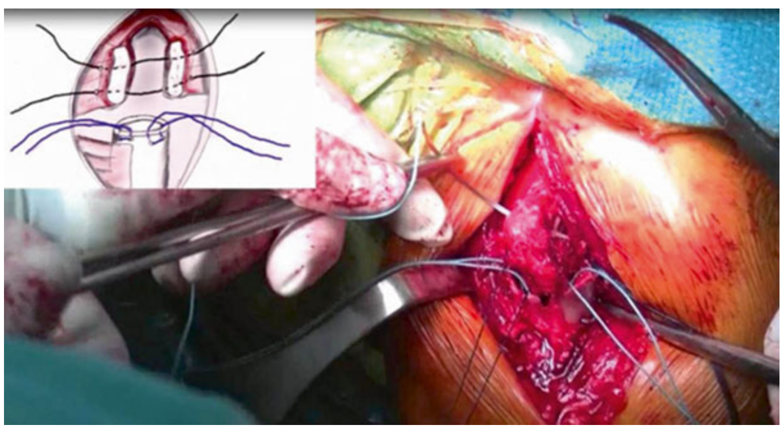

Fig. 9.12 The sutures close the fragments around the implant. Sutures passing in the supra- and infraspinatus tendons. The blue sutures come out from the canal, neutralizing the traction forces of the tendons

impingement of the implant prior to closure. The deltopectoral interval is then closed with no. 2 absorbable braided suture, followed by closure of the subcutaneous tissue with interrupted no. 0 absorbable sutures and a running no. 2/0 absorbable suture. The skin edges are re-approximated with staples and a sterile dressing applied (Fig. 9.14).

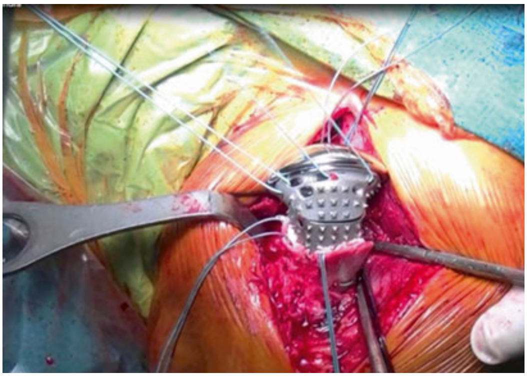

Fig. 9.13 In some cases the implant has holes to pass the sutures and ensure the tuberosities. It is mandatory to have the sutures well organized

9.4 Postoperative Management

Postoperatively, patients are immobilized for 6 weeks in a sling, which is only removed to bathe and perform physical therapy. Patients are immediately started on gentle elbow, wrist, and hand range of motion and scapular stabilization exercises. For the first 4 weeks, we allow supine passive elevation to 90° and external rotation to 30° with the arm at the side. Four to six weeks after surgery, patients are advanced to full supine passive elevation and only 30° of external rotation with the arm at the side. From the seventh week, full active forward elevation is

Fig. 9.14 Post-op X-ray control

allowed and external and internal rotations are started. Resistance exercises begin at the tenth week [8].

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