Surgical Technique

For Fractures of the Proximal Humerus
Smith & Nephew thanks the following surgeons for their participation
as part of the PROMOS™ Modular Shoulder System design team:

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Table of Contents
Introduction ............................................................................................................ 2
Indications and contraindications ..................................................................... 3
Three- and four-part fractures ........................................................................... 4
Case study ......................................................................................................... 4
Preoperative planning ......................................................................................... 5
Patient positioning .............................................................................................. 6
Surgical exposure ................................................................................................. 6
Preparation of the tuberosities/Determining the humeral head size .................. 7
Preparing and sizing the humeral canal .............................................................. 8
Assembling the stem inserter .............................................................................. 9
Inserting the trial humeral stem ....................................................................... 9
When to use half-size trial stems ..................................................................... 10
Sizing, inserting and positioning the trial body ................................................ 11
Sizing, inserting and positioning the trial inclination set .................................. 11
Inserting and optimally positioning the trial humeral head ................................ 12
Trial glenohumeral joint reduction with verification of version and stability .... 12
Trial reduction of tuberosities ............................................................................ 13
Removing trial components ........................................................................... 13
Implanting the definitive stem ........................................................................ 13
Implanting the definitive body .......................................................................... 14
The definitive inclination set ........................................................................... 15
Implanting the definitive inclination set ............................................................ 15
Implanting the definitive humeral head ............................................................ 16
Repairing and bone grafting the tuberosities .................................................... 16
Assessment of range of motion and tuberosity fixation .................................... 17
Wound closure and postoperative immobilization .......................................... 18

Nota Bene
The technique description herein is made available to the healthcare professional to illustrate the authors’ suggested treatment for the uncomplicated procedure. In the final analysis, the preferred treatment is that which addresses the needs of the patient.
This surgical technique is an addendum to the PROMOS™ Modular Shoulder System (Smith & Nephew Lit. No. 00762). It details the procedure for reconstructing fractures of the proximal humerus. The PROMOS system features easy in situ adaptability with an anatomically sized humeral head and cementless stem fixation. In addition, a unique, modular body design simplifies head height adjustment and allows secure, anatomical tuberosity fixation. The PROMOS system is indicated for both proximal humerus fractures and arthritis.
Indications, contraindications and risk factors

The therapeutic goals of implanting an anatomical humeral head prosthesis for complex fractures of the shoulder are to reduce pain and bring about functional improvement. The patient's overall medical condition and motivation for the necessary rehabilitation should influence treatment.

Indications for PROMOS™ STANDARD system include
- Advanced degeneration of the shoulder joint as a result of degenerative, post-traumatic or inflammatory arthritis
- Avascular necrosis of the humeral head
- Complex fractures of the proximal humerus
- Functional impairment especially in the case of post-traumatic loss of the joint configuration

Contraindications
- Acute or chronic infections, local or systemic
- Severe diseases of the muscles, nerves or blood vessels that put the affected limb at risk
- Lack of bone substance or poor bone quality that puts the stable seating of the prosthesis at risk
- Any concomitant condition that can hazard the function of the implant
- High-grade physical activity (eg competitive sports, heavy physical work)

Risk factors (relative contraindications)
- Distorted medullary cavity, ie juvenile rheumatoid arthritis
- Advanced osteoporosis
- Metabolic bone disorders influencing the formation of new bone
- Extreme loading (work, sport)
This technique can be used for the following complex fractures of the proximal humerus:

- Four-part fractures and fracture dislocations
- Head split and some head impression fractures
- Selected three-part fractures and fracture dislocations with moderate comminution and osteoporosis
Case study

72 year old active female with moderate osteopenia suffered a three-part fracture.

Two weeks postoperative: Anatomical reconstruction of the shoulder with the PROMOS® Modular Shoulder System utilizing cementless stem fixation.

Four months postoperative: Anatomically healed tuberosities.

Three- and four-part fractures

Hemiarthroplasty of the proximal humerus is indicated in older patients for the treatment of most four-part and head split fractures, and selected three-part fractures with moderate comminution and osteoporosis. Younger patients with an impacted valgus four-part fracture and good bone quality may be candidates for percutaneous pinning or open reduction and internal fixation. Three-part fractures with good bone quality should be treated with surgical fixation in order to preserve the humeral head. The patient's overall medical condition and motivation for the necessary rehabilitation should influence treatment.

Most three- or four-part fractures occur at or near the anatomical neck region with preservation of some or all of the humeral shaft medial calcar. The upper portion of the bicipital groove often remains attached to the fractured lesser tuberosity. Despite comminution of the greater tuberosity fracture, the axial height from its donor site on the shaft can generally be estimated. These recurring fracture patterns can often serve as an in situ template during an anatomical reconstruction.
Preoperative planning

Precision preoperative planning is indicated for fracture reconstructions because many of the normal bony anatomical guidelines available to the surgeon have been either disrupted or distorted by the fractures.

The appropriate radiographs of the proximal humeral fracture are analyzed in conjunction with radiographs of the opposite side. Radiographic templates of the stem and humeral head are used to preoperatively estimate the implant sizes. The approximate location of the original humeral shaft medial calcar is determined on the fractured humerus radiograph.

A key product benefit of the PROMOS™ Modular Shoulder System is that the surgeon intraoperatively creates the prosthesis on a fixed cementless stem in order to position the humeral head to most closely approximate the patient’s natural anatomy. No special guides or jigs are used during the reconstruction.

**Literature numbers for preoperative templates**

71281470: PROMOS STANDARD Template includes humeral head, stem with proximal body and glenoid components.

**Estimate the size of the humeral head**

Overlay the humeral head template on the radiograph of the fracture and compare it to the humeral head size from the opposite side. Select the size of the humeral head template that most closely matches the diameter of the patient’s humeral head. When trying to decide between two sizes, the smaller size should be selected.

**Estimate the location of the native humeral medial calcar**

Analyze radiographs of the fracture and of the opposite side. Mark the position of the original medial calcar on the radiograph of the humeral fracture to establish the reference level from which to attach the stem and anatomically position the humeral head.

**Estimate the size of the stem**

Select the stem template size that fills the intramedullary canal while simultaneously resting between 1.0 to 1.5cm below the natural medial calcar.

**Body and inclination set sizes**

The body and inclination set sizes are generally determined intraoperatively to restore humeral length and couple the fixed stem to the anatomically positioned humeral head.
Patient positioning

The patient is placed in a beach chair position. The shoulder extends beyond the top corner of the table and the distal humerus rests on a bolster. Remove the bolster to extend the arm for humeral canal exposure.

Surgical exposure

A standard deltopectoral incision is recommended beginning just distal to the clavicle over the coracoid process and extending to the humerus. The cephalic vein is mobilized laterally with the deltoid muscle to preserve venous outflow. The subdeltoid space is exposed and the hemorrhagic bursa is excised. The long head of the biceps tendon is identified just proximal to the pectoralis major tendon. If possible, it is preserved and exposed toward its origin by sharply releasing it from the bicipital groove and opening the rotator interval to the base of the coracoid process. An incomplete longitudinal fracture line within or adjacent to the bicipital groove is completed with an osteotome. The lesser and greater tuberosities are defined.
The lesser tuberosity and its attached subscapularis are bluntly released from the undersurface of the coracoid strap muscles. Three or four heavy (no. 5 non-absorbable) sutures are placed around the tuberosity and through the subscapularis tendon. Both tuberosities are bluntly retracted to expose the joint – the lesser tuberosity medially and the greater tuberosity laterally.

The fractured humeral head is exposed, carefully grasped with a bone tenaculum and gently removed from the joint. Any residual humeral head articular fragments still attached to the tuberosities are carefully removed. The humeral head and its fragments are pieced together. The trial humeral head that most closely approximates the diameter of the fractured head is chosen and the size is confirmed. When trying to decide between two sizes, the smaller size should be selected.

The greater tuberosity fragments with the attached spinati and teres minor tendons are tagged with three or four heavy (no. 5 non-absorbable) sutures around the tuberosity and through the attached tendons. Any residual subdeltoid adhesions are released.

The glenoid fossa is visualized and inspected. If resurfacing is necessary, see the section on Preparation of the Glenoid in the PROMOS® STANDARD Surgical Technique for Shoulder Replacement.

Mobilization of the subscapularis is completed by releasing the attachments to the base of the coracoid process. In acute fractures, this should restore proper myotendinous mobility through the attached lesser tuberosity. If additional mobilization is necessary, the axillary nerve is first identified and protected. Further release is completed by incising the capsule and glenohumeral ligaments on the deep surface of the subscapularis tendon, 1cm lateral to the labrum.
The long head of the biceps tendon and the lesser tuberosity are retracted anteromedially while the greater tuberosity is retracted posteriorly.

Bring the fractured proximal humeral shaft into the wound by removing the bolster and extending the arm in slight adduction. Position the humeral shaft perpendicular to the horizontal plane in order to broach the canal. Begin by using the smallest stem broach on the rasp adaptor. Orient the broach with 20° – 30° of retroversion.

Note: To determine the retroversion, use the elbow transepicondylar axis and the forearm (elbow flexed to 90°) as a guide. Normally, the broach will lie posterior to the remaining intact bicipital groove of the proximal humeral shaft.
Progress by broaching slowly and gently tap the broach in and out to ensure adequate positioning and to prevent fracture.

Note: The medullary canal is prepared to the broach size determined preoperatively with the humeral stem template.

Assembling the stem inserter
Assemble the stem inserter with the T-handle and the holding screw as indicated.

Select the correct size trial humeral stem as determined with the preoperative templates and confirmed by the broach size.

The trial humeral stem is placed on the inserter of the corresponding size by turning the knob of the holding screw.

Inserting the trial humeral stem
The trial humeral stem is inserted into the medullary canal at the selected retroversion (20° – 30° on average) using gentle impaction with a mallet. When the trial stem is seated and there is no evidence of further subsidence during gentle impaction, firm diaphyseal engagement is achieved. Ideally the top of the chosen trial stem should rest between 1 – 1.5cm below the estimated native medial calcar. Otherwise another trial stem size should be used.

Note: Measure the axial distance from the estimated native medial calcar to the top of the fixed trial stem. This distance will be compared to that of the fixed definitive stem.
When to use half-size trial stems
Trial stem sizes 0, 1.5, 2.5 and 3.5 are referred to as half-size trial stems. If intimate cortical engagement cannot be reached 1 – 1.5cm below the estimated native medial calcar and the next full trial stem size is found to be too high; then use of a half-size trial stem is indicated. The half-size trial stem will generally sit within the required 1 – 1.5cm range.

For very small patients, the 02 monoblock stem is available where the body is incorporated into the stem. The stem offers a choice of three heights in 5mm increments.

Authors' tip: Use the implanted definitive stem to serve as the platform on which the different trials are used in situ to anatomically reconstruct the patient's anatomy.

After the fixed trial stem is chosen, it is removed. Then, the definitive stem is implanted and solidly fixed 1 – 1.5cm below the estimated level of the native medial calcar. Different combinations of trial bodies and inclination sets are used on the fixed definitive stem to ultimately achieve the ideal position of the trial humeral head.

The T-handle torque screwdriver tightens screws
Always use the torque screwdriver to tighten implant screws.

Loosening screws with the torque screwdriver will damage the torque mechanism.

Note: Verify that when no torque is applied to the torque screwdriver, the torque indicator rests at the “Neutral” mark. The torque screwdriver is a measuring device. Do not apply impacting forces with a mallet or similar instruments in any situation as this will damage the instrument.
The modular T-handle screwdriver *loosens* screws
The modular T-handle should be used to *loosen* the screw connections.

Do *not* tighten implant screws using the modular T-handle screwdriver.

**Sizing, inserting and positioning the trial body**
The smallest trial body that clears the estimated native medial calcar is placed on top of the trial stem. The face is aligned at the chosen retroversion (20° – 30°) and securely fixed with the screw to the stem.

Normally the final body size and version are determined after optimal head position is achieved.

**Sizing, inserting and positioning the trial inclination set**
The shortest inclination set that allows clearance of the trunnion beyond the estimated native medial calcar is selected.

The trial inclination set is tightly screwed into the body with the saddle in neutral (inclination angle of approximately 135°/version angle of 0°).

The trial inclination set is used only for sizing and not for changes in version.
Inserting and optimally positioning the trial humeral head
The chosen trial head is loosely placed on the trunnion of the trial inclination set. Optimal head position is achieved when it is rotated posteriorly to reestablish the normal anatomical calcar/humeral head relationship while resting 1cm or less above the body. This will allow for greater tuberosity fixation just below the anatomically positioned humeral head while restoring the anatomical posterior offset. The trial humeral head is impacted in this position onto the trial trunnion.

Note: The PROMOS™ system features humeral heads with different eccentricities. For most fracture reconstructions, the blue trial heads with a fixed eccentricity of +4mm are used.

Trial glenohumeral joint reduction with verification of version and stability
With gentle retraction of the tuberosities, the trial head is reduced onto the glenoid fossa with the long head of the biceps tendon lying anterior to the trial head.

Humeral head version and myofascial sleeve tension are evaluated. The arm is placed at the side and in neutral rotation (elbow flexed to 90º with the forearm at 0º of external rotation). The humeral head should point toward the center of the glenoid fossa confirming the anatomical version. In this position, the newly tensioned myofascial sleeve should allow up to 40 – 50% of humeral head diameter translation in the inferior and posterior directions.

Note: When the trial glenohumeral joint is reduced, if it is determined that there is a need to adjust the version, make these adjustments by changing the version of the trial body while leaving the trial inclination set in neutral, and reduce the joint again. Make these adjustments until you are satisfied with the joint reduction.
**Trial reduction of tuberosities**
A trial reduction of the tuberosities onto the body a few millimeters below the superior aspect of the humeral head with overlap of the tuberosities onto the humeral shaft should allow for an anatomical reconstruction without undue tension.

**Removing trial components**
The trial components are removed. The head and inclination set are removed separately while the stem and the body can be removed as a unit with the extractor/impactor.

Note: If the reconstruction with the trials was performed with the definitive stem already implanted, the trials (head, inclination set and body) are removed separately.

**Implanting the definitive stem**
The definitive stem is inserted at the chosen version. After solid fixation is confirmed with no evidence of subsidence during gentle impaction, the final stem height below the estimated native medial calcar is determined. If essentially unchanged from the trial stem height, then proceed with insertion of the definitive body. Otherwise, a different combination of bodies and inclination sets may be required for an anatomical reconstruction.
Implanting the definitive body
The chosen definitive body is placed on the cleaned, dry stem cone and aligned at the chosen retroversion (20° – 30° as determined on page 8).

Note: Both the trial and the definitive body should be implanted at the chosen version.

The definitive body is pressed onto the distal stem with the aid of the clamp for in situ assembly (1). The two-part connection screw (2) is introduced into the assembly clamp, and the adaptor (3) corresponding to the body height is mounted on the assembly clamp. The assembly clamp is placed on the body and the connection screw is tightened to the distal stem with the clamp handles wide open. When the clamp handles are squeezed together, the body is fixed to the stem without driving the stem deeper. Then the connection screw is tightened again and the clamp handles are pressed together. This process should be performed a total of three times. The force applied is sufficient to achieve a stable joint between the body and the stem. The clamp is now released and removed.

If necessary, there is a holding block and a holding fork when assembling the implant on the back table.

The connection between the body and the stem is also secured with the included screw. The screw is tightened using the torque screwdriver to the “Implant” mark.
The definitive inclination set
This inclination set is comprised of an internal cone and a sleeve. The internal cone screws into the definitive body. The sleeve is impacted over the internal cone. Both the internal cone and the sleeve are aligned with holding discs.

Note: The size of the trial inclination set determines the size of the definitive inclination set. Both the trial and the definitive inclination sets are implanted in neutral (inclination angle 135° / version angle of 0°).

Implanting the definitive inclination set
Place the primary alignment disc on the internal cone with the 0 aligned with the laser etch of the implant. Disregard the remaining numbers on the disc, as they have no specific meaning. The internal cone is screwed into the definitive body with the laser mark and 0 north. Remove the disc. While using the holding fork to apply counter torque, tighten the screw with the torque screwdriver to the “implant” mark, twice.

With the laser etched “Top” facing the surgeon, place the sleeve alignment disc over the flat surface of the sleeve. Firmly press down on the disc. Confirm that the sleeve will remain in place while only the disc is held. While the sleeve remains centered in the disc, place it over the internal cone. Using the disc as a handle, rotate the Sleeve so that it becomes parallel to the surface face of the body (inclination angle 135° / version angle of 0°). When satisfied, impact the sleeve using the sleeve/head impactor. The disc may then be removed.

Note: The definitive inclination set should be impacted prior to using a trial or definitive humeral head.

If necessary, an impacted definitive inclination set can be disassembled by positioning it between the sleeve/head impactor, as shown. A light hammer blow to the upright impactor will loosen the components.

Note: An impacted inclination set may be disassembled and re-impacted only once before implantation.
Implanting the definitive humeral head
The definitive humeral head is then loosely placed on the dry, cleaned trunnion of the definitive inclination set. The head is rotated posteriorly and optimally positioned by restoring the normal humeral/calcar relationship while resting 1cm or less above the body. With three gentle blows of the mallet on the impactor, the humeral head is securely fixed in place.

Note: After impaction of the head onto the trunnion of the inclination set, the fixation can be assessed manually.

The glenohumeral joint is then reduced. Joint version and stability are reassessed prior to tuberosity fixation.

Repairing and bone grafting the tuberosities

Secure tuberosity fixation to the body is achieved using three heavy (no. 5) non-absorbable sutures around each tuberosity and through its attached rotator cuff tendon(s). An additional heavy (no. 5) tape (Mersilene™ or Dacron™) is placed through the large medial hole of the body and then around the upper half of each tuberosity. A second tape can be used through the same medial hole and then passed around the lower half of each tuberosity.

The tuberosities are reduced onto the body with the rotator cuff tendons covering the humeral head. The three greater tuberosity no. 5 sutures are threaded through the lateral holes of the body using the upper hole, one of the two middle holes and the most inferior hole. Similarly, the three lesser tuberosity no. 5 sutures are threaded through the lateral body holes using the upper hole, the unused middle hole and the inferior hole.
To enhance healing of the tuberosities to the humeral shaft and to each other, a sliver of primary cancellous humeral head bone graft is fashioned to each side of the body and attached by wedging it into the medullary cavity.

First, the greater tuberosity is reduced onto the body just below the superior aspect of the humeral head and overlapping the humeral shaft inferiorly. Secure fixation is achieved by tying the three no. 5 sutures. Next, the lesser tuberosity is reduced and fixed with the three no. 5 sutures. The upper tape is then tied beneath the biceps tendon, securing both tuberosities to each other and to the body. Then the lower tape is tied over the biceps tendon, further securing both tuberosities and securing the biceps tendon.

Assessment of range of motion and tuberosity fixation
While under anesthesia, the quality of tuberosity fixation and the range of motion are assessed. The acceptable limits of early postoperative, passive range of motion are determined.
The rotator interval is closed with no. 2 non-absorbable sutures in external rotation to prevent a loss of rotation. An optional drain can be placed. The wound is then closed in layers using subcutaneous and skin sutures. A sterile dressing is applied and the arm is immobilized in a sling.

**Implants**

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<th>Stem, non-cemented</th>
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<td>42177</td>
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*Need to be ordered separately. Refer to Lit. no. 00762 for more details.
### Body

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### Inclination set

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### Humeral head

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Please note that all humeral stems are compatible with all bodies; all bodies are compatible with all inclination sets; and, all inclination sets are compatible with all heads.

The glenoid component is, however, specific to head size and so the information for the PROMOS™ Modular Shoulder System Surgical Technique will be provided as shown in the following table.

<table>
<thead>
<tr>
<th>Humeral Stem</th>
<th>Body</th>
<th>Inclination Set</th>
<th>Head</th>
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