Anatomical Shoulder™ System

Surgical Technique

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Anatomical Shoulder System

Cemented Shoulder Prosthesis
Uncemented (Press-Fit) Shoulder Prosthesis

Indications
- Primary and secondary osteoarthritis
- Arthritis of the shoulder (rheumatoid arthritis, ankylosing spondylitis, etc.)
- Avascular necrosis of the humeral head
- “Cuff-tear arthropathy”
- Complex fractures of the proximal humerus
- Post-traumatic malposition of the proximal humerus

Contraindications
- Acute infection
- Neuroarthropathy shoulder (Charcot shoulder)

See also package insert
Preoperative Planning

Three radiographic images of the shoulder joint are required for planning the operation:

1. Full-size anterior-posterior view with neutral rotation (0°), centered on the articular cavity
2. Axial view
3. CT scans for planning the glenoid insertion

Preoperative planning – humerus

After aligning the humeral stem on the anterior-posterior x-ray at 0°, place the humeral-head template on the stem template and determine the size of the head of the prosthesis.

If there is marked deformation of the head, planning should be based on the healthy contralateral joint.

Determine the size of the stem of the prosthesis on the basis of the anterior-posterior and axial x-rays.

The stem should approximately fill the medullary canal, both proximally and distally. Eccentricity and retrotorsion are adjusted intra-operatively.

The Anatomical Shoulder Prosthesis allows a defined retrotorsion angle range between –30° and +30°. The gradual adjustment of the eccentricity of the Anatomical Shoulder which takes this into account is from 2 mm (diameter 40 mm) to 7 mm (diameter 52 mm).

For proximal fractures of the humerus, please use the Anatomical Shoulder Fracture System. See surgical technique Lit. No. 06.01288.012.

Template Options

Templates Anatomical Shoulder System
- Anatomical Shoulder Humeral Stem, cemented/uncemented (press-fit) Lit.No. 06.01313.000
- Anatomical Shoulder Humeral Stem Revision, cemented Lit.No. 06.00641.000x
- Anatomical Shoulder Humeral Head Lit.No. 06.00642.000x

Comment.
X-ray templates are magnified by 10%.
Preoperative planning – glenoid

Preoperative CT investigation is recommended whenever a total shoulder prosthesis is used. If there is a defect in the posterior glenoid, this must be corrected either by corrective reaming or by bone reconstruction (using the resected head).

As illustrated below, measure the first horizontal CT section below the tip of the coracoid process and read off the glenoid version (\(\alpha\)) (Fig. a) (any osteophytes must be identified and not taken into consideration). Determine the correction angle on the basis of the measured glenoid version, knowing that the coronal (physiological) retroversion amounts to between 0° and 10° (retro). Example angle \(\alpha = 20°\) retroversion measured – 15° retro correction to a final retroversion of 5° (Fig. b).

Enter the correction angle you have calculated on the glenoid positioning guide. Care must be taken both while drawing and during surgery, to ensure that the glenoid positioning guide lies on plane a-a (Fig. b).

Carry out cranio-caudal alignment of the Kirschner Wire under visual monitoring.

Then set this correction angle on the glenoid positioning guide, keeping in mind that one graduation mark corresponds to 5° (see page 17).

Optional

If the need of an exact inferior/superior (\(\alpha_1, \beta_1\)) and/or retroversion correction (\(\alpha_2, \beta_2\)) is identified during preoperative planning with CT-scans, the optional 3D Guiding Instrument (with 5° steps laser marks) can be used (Fig. e).

A preoperative CT scan is recommended for the purpose of determining the possible need for realignment of the articulating surface. The target value is a coronal (physiological) retroversion of between 0 and 10° (retro) (Fig. c and d).
The mismatch of the radii of the glenoid and of the humeral components allow a slight rolling and sliding movement of the head to absorb shear loads.

The glenoid surface can be reamed with the available reamers to achieve congruence between the anatomical glenoid and the rear surface of the glenoid component, thereby minimising the so-called rocking-horse effect, so that a low glenoid loosening rate can be expected.

The convex design preserves more bone, reduced lumped and shear loads and responds better to eccentric loads than a design with a flat posterior surface.

<table>
<thead>
<tr>
<th>Humerus head-glenoid “mismatch” in mm</th>
<th>S</th>
<th>M</th>
<th>L</th>
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<tr>
<td>40</td>
<td>6.5</td>
<td>8</td>
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<tr>
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<td>4.5</td>
</tr>
</tbody>
</table>

The preferred combination is shaded.
Surgical Technique
Positioning of the Patient and Approach

The patient should be placed in a beach chair on the edge of the operating table (Fig. 1). The arm must be freely movable and it must be able to extend it fully. An armrest is optional.

Make a skin incision in a straight line starting from the lateral edge of the coracoid as far as the insertion of the deltoid muscle. Seek out the cephalic vein between the deltoid muscle and the pectoralis major muscle. Make the approach medial to the vein (Fig. 2).

Rotate the arm outwards as far as possible and bring the subscapularis muscle into the field of vision (Fig. 4).

After exposing the subacromial space, retract the deltoid muscle with a deltoid retractor.

Retract the common tendon of the short biceps and the coracobrachialis muscles with a Langenbeck retractor (Fig. 3).

Make a vertical incision 1 cm lateral to the muscle tendon junction of the subscapularis, so that approximately 1 cm of tendon remains attached to the muscle. Alternatively, it is possible to detach the tendon of the subscapularis muscle either subperiostally or with an osteotome from the lesser tuberosity, securing it back into place transosseously after the operation (see also page 9, Figure 6).

Mobilize the subscapularis muscle by means of a capsulotomy and looping 4 to 5 strong non-absorbable sutures around it (Fig. 5). An incision into the coracoacromial ligament should be made only in exceptional cases.

Adduct the arm and put the humerus retractor (ring retractor) into place, so that the glenoid can be exposed. Pulling on the subscapularis muscle, to expose and protect the axillary nerve with the arm both adducted and flexed.
If there is pronounced internal rotation contracture, it may be necessary to undertake partial release of the subscapularis muscle from the fossa (Fig. 6).

After exposing the axillary nerve, remove the ring retractor and dislocate the humerus by rotating it externally. The proximal end of the humerus is now free. Keep the arm adducted, rotated externally, and extended. Place a blunt Hohmann retractor on the calcar and carefully remove all the osteophytes from the anatomical neck using a ronguer. Expose the attachment of the cartilage to the humeral head by inserting an 8 mm hook behind the biceps tendon (Fig. 7).
Humeral Head Resection

The humeral head should be resected exactly at the level of the anatomical neck.

In the superior and anterior superior aspects, the anatomical neck corresponds to the insertions of the tendons of the cuff (supraspinatus and uppermost section of the subscapularis). In the inferior aspect, there is a smooth transition between the cartilage of the head and the cortical bone of the humerus.

In the posterior aspect, in the region of the infraspinatus and teres minor, is the sulcus, which is a groove of 6 to 8 mm in length, without cartilage or attached tendons.

The resection must start exactly on the cartilage. Do not resect the cartilage-free area.

Retrotorsion Adjustment

The Anatomical Shoulder Heads allow an retrotorsion angle between –30° and +30°.

After the osteotomy of the humeral head, the point of insertion of the reamer can be marked with a 3 mm awl under the highest point of the resection, directly medial to the bicipital tendon (Fig. 9).

For this purpose, the arm is externally rotated and extended and the elbow is rested on the body.

If a glenoid is used

The plane of the humeral resection can be protected with a disk-shaped protector (Fig. 10). Disks of three different diameters (40, 44 and 48) are available. The pins on the lower side of the disks are inserted at the level of the incision (glenoid, preparation and implantation; see page 17).
After opening the medullary canal, the proximal section of the humerus is prepared with the aid of modular rasps, starting with rasp size 7 (Fig. 12).

The fin is directed towards a point approximately 9 mm behind the sulcus. The proximal section of the humerus is then prepared stepwise with rasps of size 9, 10.5, 12 and 14, up to the size of the previously used reamer (Fig. 13).

**Retrotorsion Adjustment Technique**

Insert the alignment rod into the appropriate retroversion hole on the handle for rasp. Use the right or left hole for the corresponding shoulder side and the preferred hole for orientation to the forearm or to the condyles (Fig. 14).

Care should be taken to ensure that the rasps are fully inserted into the humerus, i.e. until the movable cross-pin is visible on top and contacts both anterior and posterior metaphyseal surfaces (Fig. 16).

**Note**

If full insertion of the rasp to this extent is not successful, the uncemented (press-fit) shaft of this size may not be used.

The rasp handle is now removed and the modular rasp left in the humerus. The rasp is now seated 5 mm below the resection line (Fig. 17).

The rasped lateral fin is now visible posterior to the bicipital tendon.

**Cement mantle:**

The average thickness of the cement mantle is 1 mm.

**Press-fit:**

The average press-fit is 0.55 mm. The distal fins generate the mayor part of the press-fit.
Optional
Additional fixation of the modular rasp in the humerus can be performed by inserting a rasp fixation screw into the modular rasp (Fig. 18) (this is recommended if poor bone quality). This ensures that the rasp will not subside when the humeral head is impacted onto it.

The preparation of the humerus is now complete.

The size of the head of the prosthesis to be used is determined by means of a comparison with the resected humeral head and, in particular, with the resection area of the humerus. If osteophytes are present, they must be removed before this comparison. The diameter is the most important criterion for head size (Fig. 19).

The diameter is fixed as the first parameter.

The head height must also be selected for diameters of 48, 50, 52 mm (Fig. 20).

The selected humeral head test prosthesis is inserted onto the test Ball-Taper (Fig. 21).

All grub screws must be tightened in place again outside the internal ball of the head (Fig. 21a).
The loosely connected humeral test prosthesis is placed on the modular rasp in the humerus, so that the underside of the head is resting on the humerus (Fig. 22).

The Trial Head is turned with the aid of an Allen wrench, until it covers the area of the humeral resection incision, resulting in an exact anatomical restoration of the resected head (Fig. 23, 24).

Use the Grub Screws to keep the Trial Head in proper position. Thighten two screws that face you first; then remove the Head and tighten the remaining three screws. Place the Trial Head and Ball-Taper back on the Rasp to begin Trial reduction.

The offset laser marking of the humeral head test prosthesis is transferred to the humerus by an incision and the humeral test prosthesis is then removed from the humerus.

The definitive prosthesis shaft (of the size determined by the last used modular rasp) the Ball-Taper component, the Expansion Cone and the set screw are unpacked.
The Expansion Cone is then placed into the Ball-Taper component (Fig. 25).

The Expansion Cone is fixed into the Ball-Taper component using the insertion rod, without causing any spreading (Fig. 26).

The definitive prosthetic head is now unpacked. The size of the head has been defined by the previously used Trial head.

The head is now inserted into the Ball-Taper component as shown (Fig. 27).

The implant is now loosely assembled and the Expansion Cone is located inside the Ball-Taper component (Fig. 28).

The Ball-Taper should be able to move freely in the head (Fig. 28a).

The assembled head is now fitted onto the oval internal profile of the modular rasp (Fig. 29).

The head is adjusted so that it covers the resection plane of the humerus.

The gap between the under side of the head and the resection plane is required before fixation. When the head is set parallel with the incision on the humerus and the head covers the resection plane in inclination, retroversion and offset, so prefix the head to the Ball-Taper component. Use three consecutive defined impulses from the Impactor for impaction (Fig. 30).

**Note**

Care should be taken to ensure that the Impactor is pressed centrally onto the ball area of the head and up to the maximum compression of the spring, before the three defined pulses are triggered.

Charging the impactor see page 25.

These pulses propel the Expansion Cone inside the Ball-Taper component towards the ball. The Expansion Cone is spread and the head is prefixed on the Ball-Taper component.

The prefixed head component is now removed from the modular rasp (Fig. 31). The inclination, retroversion and offset have now all been prefixed.
The screw is unpacked and inserted from the lower side of the head into the Ball-Taper component using the socket wrench. The screw is then screwed loosely into the Ball-Taper component until it sticks (Fig. 32).

The head implant is then inserted into the assembled mounting block and lightly fixed with the threaded rod (Fig. 33).

The head prosthesis has now been permanently fixed (Fig. 35) and can be carefully removed from the assembly block.

The stem prosthesis is now placed into the stem holder (Fig. 36).

**Note**
Before the prosthesis head can be placed on the prosthesis shaft, the cones must be carefully cleaned of blood and possible other residues.

The prosthesis head is now finally impacted onto the prosthesis stem with the aid of the Impactor (Fig. 37).

**Note**
Care should be taken to ensure that the Impactor is centrally located on the ball surface before the defined pulse is triggered (Fig. 37).

The humeral implant has now been prepared specifically for this patient (Fig. 38).

Connect the Torque Wrench for Humeral Head to Nut for Torque Wrench 4.5 mm (Fig. 34).

The offset incision on the humerus is now examined, to see whether this is medial or lateral and anterior or inferior on the humerus. The head prosthesis is now placed on the stem prosthesis, after appropriate rotation (Fig. 36).
The modular rasp can now be removed from the humerus (Fig. 39). If the rasp screw has been used it must be removed first. The rasp handle cannot be mounted without removing this screw.

If the rasp handle cannot be attached, the modular rasp can also be removed from the humerus by means of the rasp extraction instrument (Fig. 40).

Implantation of the prosthesis into the humeral shaft
With the cemented prosthesis, a cement restrictor can be inserted into the humerus, followed by the cement, in a relatively fluid consistency.

The implant is now inserted into the humerus (Fig. 41), by applying controlled force with the thumb on the head.

Note
If it is not possible to seat the implant with the thumb until you reached a maximum of 1cm distance (Fig. 42) between proximal humerus resection line and the bottom of the humeral head, extract the implant and re-ream with the last rasp size used.

The lateral stem fin is used as orientation.
The implant is brought into the final position with careful blows on the Impactor for humeral stem. This is done until the lower side of the Humeral Head is resting on the humerus. If the cemented prosthesis is being used, excess cement is then carefully removed (Fig. 43, 44).

The end the subscapularis is repaired using heavy, non-absorbable sutures either end to end or with transosseous sutures. The repair is started with a suture which adapts the lateral most aspect of the rotator interval.

Glenoid preparation and implantation see page 17.

Stitch the subscapularis and the supraspinatus tendons to each other with absorbable thread (Fig. 45). At this point, also reconstruct the rotator cuff if required.
**Glenoid Preparation**

After removal of all the glenoid osteophytes (Fig. 46), a ring retractor is inserted and the proximal humerus levered out posteriorly. The inferior capsule must be incised carefully preserving the axillary nerve. Attention should be paid that the axillary nerve is protected. The caudal capsule is incised and the glenoid exposed.

![Fig. 46](image)

Set the correction of version determined from the preoperative CT scan on the positioning guide (see page 6). Identify the optimal position for the guide pin and introduce the Guiding Pin/Kirschner Wire.

![Fig. 47](image)

Introduce the Guiding Pin/Kirschner Wire into the Guiding Instrument for Glenoid.

The laser marking on the 3 mm Kirschner Wire (a) must disappear slightly into the eyelet of the positioning guide (Fig. 47).

After this, remove the positioning guide over the 3 mm Kirschner Wire.

The 3 mm Kirschner Wire is now perpendicular to the required alignment of the articulating surface, which was determined preoperatively (see page 6).

The reamer and then the handle are mounted on the guide wire. For sclerotic glenoids the separate reamer (Fig. 47a) may be used to start the reaming process.

![Fig. 47a](image)

Now ream the glenoid on the basis of the reamer size and ream in the new alignment of the articulating surface (Fig. 48).

The size of the last-used reamer corresponds to the size of the glenoid.

If selection of the prosthetic components is difficult, it is generally preferable to err towards smaller heads and towards larger glenoids.

**Note**

A sizes of glenoids can be combined with all sizes of humeral heads (see “the Glenoid Component” page 7).

**Optional:**

If the need of an exact inferior/superior and/or retroversion correction is identified during pre-operative planning with CT-scans, the optional 3D Guiding Instrument (with 5° steps laser marks) can be used.

Continue with the pegged glenoid preparation on page 18 or with the Keeled Glenoid preparation on page 19.
Glenoid components with 4-peg anchoring

Now guide the Glenoid Drill Guide (left and right version) with the central hole along the 3 mm Kirschner Wire and place it on the surface of the glenoid. The Glenoid Drill Guide can be secured in place by means of a drilled centering peg (Fig. 49).

The proximal hole, with a diameter of 6.2 mm, is now bored with the glenoid drill. Care should be taken to ensure that drilling is continued as far as possible with the Glenoid Drill Guide (Fig. 50). The drill can be used with either the flexible or the rigid shaft.

Engage all the holes with the countersink in order to enable seating of the glenoid component (Fig. 54).

Now insert the Glenoid Trial prosthesis into the prepared glenoid, using the holding forceps (Fig. 55).

The third bored hole is now fixed and the 3 mm Kirschner Wire and the centring pin are removed (Fig. 52).

Now drill the central hole (Fig. 53).
Glenoid component with keel

Now guide the Glenoid Drill Guide with the central hole along the 3 mm Kirschner Wire and place it on the surface of the glenoid.

The Glenoid Drill Guide can be secured in place by means of a drilled centering peg (Fig. 56).

**Note**

The Glenoid Drill Guide is available in two sizes: S/M for the Keeled Glenoid sizes S and M, and size L for the Keeled Glenoid size L. Both sizes are available in left and right version.

The proximal drilled hole is then fixed with a centering pin and the distal hole is drilled (Fig. 56). The second hole is then also fixed with a centering pin. The 3 mm Kirschner wire and the centering pin are removed.

Now drill the central hole approximately 5 mm into the glenoid (Fig. 56). Remove the two pins afterwards. Now drill the central peg until you have reached the Glenoid Drill Guide stop.

To help ensure optimal preparation of the bone to the keel glenoid, as a final step the bone is processed into a keel with a rasp (Fig. 57). This step gives optimal concentration of the bone.

If drill guide of sizes S or M were used, use Rasp size S and M. The rasp of size L is used, if the size L drill guide was used.

The glenoid test prosthesis is inserted into the prepared glenoid using the holding forceps (Fig. 58).
Cementing
The glenoid trial prosthesis is used to test whether the seating is stable (Fig. 59).

The glenoid surface and the anchoring holes are now carefully cleaned and dried. The anchoring holes are filled with bone cement and the cement is pressed into the anchoring holes with a clean compress or using the instruments shown in (Fig. 60 and 61). Glenoid Cement Setting Instrument for pegged glenoid can be used for all three sizes S, M and L (Fig. 60).

The Glenoid Cement Setting Instrument for a Keeled Glenoid consists of a handle and two pressurization adapters in size S/M and L (Fig. 61).

The anchoring holes are then filled where necessary and cement is applied to the glenoid surface and the back side side of the implant.

Postoperative Treatment
It is the responsibility of the doctor to decide which postoperative treatment is appropriate depending on each patient’s health condition.

The following outlines recommendations which are generally made by doctors.

From the first day after the operation the patient takes the arm out of the immobilizing dressing several times a day to stretch his elbow. On the day of the operation pendulum exercises are generally started, on the first day with passive flexing exercises, best performed using a cord passed over a roller. Depending on the intra-operative findings, active exercises can be started from the third week. If the rotator cuff was sutured or reconstructed, an abduction splint may be necessary for 4 to 6 weeks.

Note
Do not use the Impactor on the implant while the cement is hardening.

The excess cement is immediately and carefully removed with a knife blade.
Removal of the Implant Head

After exposing the axillary nerve, remove the ring retractor and sublux the humerus by externally rotating it. The proximal end of the humerus is now free. Keep the arm adducted, rotated outwards and extended. Place a blunt Hohmann retractor on the calcar and carefully remove all the osteophytes from the anatomical neck using a ronguer. Now expose the attachment of the cartilage to the humeral head by inserting an 8mm hook behind the biceps tendon.

With a cemented humeral stem the humeral head is removed of cement with a Lexer chisel so that the extraction instrument can be applied. The extraction instrument is now applied to the humeral head and fixed with a two-edged screw (Fig. 63). With the aid of the Extractor instrument and the slide hammer weight the humeral head is separated from the humeral stem parallel to the lower side of the humeral head (Fig. 63).

To remove the cement from the thread if the humeral stem is cemented, a drill jig is first inserted into the oval cone of the humeral stem and then used to guide the drill (Fig. 64). Care should be taken to ensure that drilling is continued as far as possible.

Any remaining cement is now removed from the thread in the stem with the Thread Cutting Head (Fig. 65).
The X-pin is now screwed into the humeral stem (Fig. 66). The X-pin guides the reamer and is essential for directing and fixing the new head. Care should be taken to ensure that the X-pin is fully screwed in and that the oval internal cone is not damaged when this happens.

To remove the cement above the oval cone, use the Milling Cutter (Fig. 67). Reaming is performed using the cannulated handle from the glenoid tray.

The resection plane is recreated using the oscillating saw.

The plane of the humeral osteotomy is then protected with the humeral head protector (see page 10, Fig. 10).

Glenoid preparation and implantation can start – see page 17 of this surgical technique.

After completing treatment of the glenoid, examine the removed humeral head with the Ball-Taper fixed to it for damage.

It is the responsibility of the surgeon to establish without doubt whether the removed humeral head is still in perfect condition with the Ball-Taper fixed in place. If this is the case, a surgeon may place the same humeral head back on the humeral stem in the same position as before, positioning the oval cone with the required orientation.

Otherwise, a new humeral head with a new Ball-Taper must be prepared and then inserted.

The cone plug connection between humeral head and humeral stem must be clean and dry when they are impacted together.
Removal of the Implant Stem

The Humeral Stem Setting Instrument with Extractor is used if the humeral stem must also be removed after removal of the humeral head and reaming of the resection plane.

The Humeral Stem Setting Instrument is positioned on the cone of the stem (Fig. 68). The Humeral Stem Setting Instrument is fixed tightly on the humeral stem, using the tightening screw which is screwed into the thread of the stem. The tightening screw is tightened with the Hexagonal Wrench.

The Extractor with slide hammer weight can now be screwed onto the Humeral Stem Setting Instrument.

The implant stem is now removed from the humeral canal with energetic blows.

**Note**

If the ball head cannot be removed with the humeral head, a monoblock construct must be accepted. A readjustment of the humeral head on a humeral stem of this type is not possible, the implant stem must be fully removed.

The Milling Cutter is passed over the tapered ball of the implant, opening up a free position for applying the stem extraction instrument (Fig. 69).

Reaming is performed using the cannulated handle from the glenoid tray.

The stem extraction construct consists of a Split Chuck, an Adapter and a screw (Fig. 70).

This extraction construct is required for the removal of the Humeral Stem. The Split Chuck is first placed on the ball. The Adapter is then placed over this Split Chuck. The screw is tightened, resulting in a secure connection between the Split Chuck and the Adapter (Fig. 70).

The Extractor instrument with slap hammer weight can now be connected (Fig. 71). The implant is now removed from the humerus along the shaft axis.

In order to increase the efficiency of the extraction process an extension rod can be used. This extension rod is to be placed between the handle and the adaptor of the extractor.
Preparation and Description of the Assembly of the Instruments

Assembly block for the humeral head
Assembly and disassembly of the Impactor

Charging the Impactor

Tense the Impactor with the help of the loading aid (charger).

The Impactor is connected through the shaft of the charger.

There are two possible procedures:
Either the charger is placed on the table (Fig. 72), or the charger is held in one hand, the Impactor in the other (Fig 73, 74), while the shaft of the charger is inserted into the Impactor and tenses the Impactor.