Shoulder prosthesis

Surgical technique

DUOCENTRIC®
Fracture system

ASTON®
Orthopaedic Implants
Introduction

It is generally accepted that displaced four-part fractures are best treated with a hemiarthroplasty. Although a favourable outcome in terms of pain relief can be expected, function is often not satisfactory. The key to success of a hemiarthroplasty is a functional rotator cuff mechanism. Prerequisites for adequate rotator cuff function are

1) An anatomic reconstruction of the point of action of the rotator cuff, restoring the force couple balance in the glenohumeral unit
2) A permanent fixation of the tuberosities with the addition of bone grafts to augment the bone stock, but without disturbing the normal contour of the proximal humerus, to allow unrestricted movement under the coraco-acromial arch
3) A strong intraoperative fixation, allowing early rehabilitation.

Especially in the elderly, these goals are hard to achieve because of extreme fracture comminution with bone loss and loss of bony landmarks, and because of osteoporosis compromising fixation strength.

The Duocentric fracture system allows an anatomic reconstruction of the rotator cuff insertion around the prosthetic head, independent of the bone quality. This new design has several holes at the rim of its articular component to which the bone-tendon junction of the rotator cuff is fixed.

Our prosthetic design does not depend on the tuberosities for the initial restoration of the rotator cuff mechanism. The bone-tendon junction of the rotator cuff, which often remains the only useful landmark, is fixed to the holes in the enlarged rim of the prosthetic head. By creating an anatomic soft-tissue repair to the prosthetic head (Figure), the reconstruction is built up from the glenoid, rather than from the humeral diaphysis. This allows an anatomic reconstruction of the glenohumeral unit.

Restoring the glenohumeral unit first, reduces a complex 4-part fracture to a 2-part fracture, overcoming the difficulties with accurate version and offset.

Permanent fixation requires bony union of the tuberosities. It is generally accepted that bone stock of the tuberosities should be augmented with bone grafting. Intraoperative sealing of the bone-tendon junction to the articular rim theoretically safeguards containment of the bone graft, and prevents secondary displacement of the cuff insertion by graft addition. Furthermore, the head of this prosthesis is hollow, allowing generous bone grafting under the tuberosities without disturbing their normal anatomic contour.

The strength of this tuberosity fixation has been investigated in a cadaver study. This fixation method proved to be reliable in the force range of activities of daily living without significant displacement of the fracture fragments.

System Highlights

Prosthetic Stem
T-shape to increase rotational stability.
Common stem for conversion to reversed total shoulder prosthesis in case of rotator cuff failure.

Prosthetic neck
The prosthetic neck is narrow to allow generous bone grafting thereby enhancing the tuberosity healing.

T-shape to ease intraoperative orientation and handling. Medial and lateral hole to permit ‘conventional’ tuberosity attachment if required.

No lateral fin to avoid too posterior positioning of the greater tuberosity and too lateral positioning of the lesser tuberosity.

1) Fracture Head
   a) Several holes at the rim of its articular component to which the bone-tendon junction of the rotator cuff is fixed to allow an anatomic reconstruction of the glenohumeral unit. Restoring the glenohumeral unit first, reduces a complex 4-part fracture to a 2-part fracture, overcoming the difficulties with accurate version and offset.
   b) Polished holes to prevent suture failure.
c) Sutures through these holes directly oppose the direction of muscle pull. The loops are short and therefore less at risk for being cut by friction in the holes of the prosthesis.
d) The prosthetic humeral head is hollow, allowing generous bone grafting under the tuberosities without disturbing the normal anatomy.

2) Rationale for simplifying height and retroversion.
   a) Height: a prosthesis positioned too high causes detachment and migration of the greater tuberosity. Because the glenohumeral unit is anatomically restored this is unlikely to occur.
   b) Retroversion: An excess of retroversion can produce a detachment and migration of the greater tuberosity. Because the glenohumeral unit is anatomically restored at the bony-tendinous junction increase in retroversion will only limit internal rotation in favour of internal rotation (comparable to a humeral rotation osteotomy).

3) Rationale for a standardized tuberosity fixation.
   a) With the conventional technique (passing sutures through the prosthetic fin) the tuberosities cannot be adjusted and securely immobilized. Very often they are overtightening resulting in a frank malpositioning (too low, too anteriorly/posteriorly) creating an abnormal stress on the rotator cuff with increased risk for rupture.
   b) Use of circumferential suturing of the rotator cuff at its bony-tendinous junction to the rim of the prosthetic head is simple, reproducible and secure.
   c) Use of medial cerclage could enhance ischemia of the tuberosities with increased risk of late tuberosity resorption as final result.
THE DUOCENTRIC FRACTURE SOLUTION

a) Low profile.

b) Holes circumferential at the rim of the prosthetic head to allow firm and reproducible fixation of the rotator cuff at the bony-tendinous junction to restore an anatomical reconstruction of the glenohumeral unit.

c) Eccentric head (three positions) allowing an optimal posterior offset determined by the reconstructed rotator cuff.

d) Hollow head allowing additional bone grafting

e) Narrow stem to minimize bone loss.

f) The same stem allows conversion to a reversed total shoulder arthroplasty.

PATIENT POSITIONING

Place the patient in a semi-Fowler position (beach chair). Place the patient head in a horse-shoe like headrest (McConnell) and ensure you have free access to the whole aspect of the shoulder. Position the patient so the involved shoulder extends over the edge of the table with the arm resting on a support. Secure the patient chest and head with tape. Use a drape to isolate the anaesthesia equipment from the sterile field.

DELOPECTORAL APPRAOCH (if desired this procedure can also be performed through a DELTOID SPLIT approach)

A skin incision is made from the tip of the coracoid process down to the anterior aspect of the arm, slightly laterally to the axillary fold to avoid post-operative scar retraction. Locate the delto-pectoral groove and open it after location of the cephalic vein. A gap is usually found superiorly between the deltid and the pectoralis major muscle. Retract the cephalic vein laterally to preserve the venous drainage of the deltoid muscle. Develop the deltopectoral interval. Release the clavpectoral fascia laterally from the tip of the coracoid process and beneath the coraco-acromial ligament, which is preserved. If required a partial tenotomy of the upper pectoralis major attachment can be performed. Retract the conjoined tendon medially and identify the musculocutaneous nerve if so desired. The
nerve usually penetrates the conjoined muscle three to five cm inferior to the tip of the coracoid process. When retracting the conjoined tendon take care of the nerve! Identify the long head of the biceps and release the transverse humeral ligament and the rotator interval to free the superior border of the subscapularis. The biceps tendon remains as a landmark between the greater and the lesser tuberosity. After the subscapularis borders are identified together with the lesser tuberosity, the axillary nerve can be palpated along its anterior surface. Traction on the lesser tuberosity will ease identification. Identify the greater tuberosity and place a stay suture to facilitate head retrieval.

HUMERAL HEAD EXTRACTION AND MEASUREMENT.

The diameter of the resected humeral head is measured by callipers. Order the definitive head with the holes around its rim in the appropriated size. Place it on the special head holder. Please make sure you have the correct the head size as this is already the definite implant. Changing the head afterwards would mean replacing all the following sutures, substantially increasing the surgical time.

SUTURE PLACEMENT AROUND THE DEFINITIVE PROSTETIC HEAD.

Make sure you take a new suture for every stitch. This will allow you to do trial reductions before finally tightening the cuff around the humeral head.

The intra-articular part of the long head of the biceps tendon is resected.

Place the first suture (ethibond 2, or ticron 5) from outside-in to the upper border of the subscapularis tendon at the bony-tendinous junction. Give this suture a different colour compared to the rest. Hold the humeral head with the special holder so that all the holes are facing upwards. Pass the first suture through the 4th hole of the prosthetic head (starting to count from antero-inferior) at the anterior side of the humeral head from outside-in. Then pass it through the 5th hole of the prosthetic head (above the previous one) from inside-out. Then continue to pass the suture from inside-out to the anterior border of the supraspinatus tendon. Secure this first suture with a clamp.

Take a new suture. Place the second suture (ethibond 2, or ticron 5) from outside-in at the same level of the first suture of the subscapularis tendon at the bony-tendinous junction. Pass through the 4th hole of the prosthetic head (starting to count from antero-inferiorly) at the anterior side of the humeral head from outside-in. Pass through the 3rd hole of the prosthetic head from inside-out and continue to pass the suture from inside-out through the subscapularis tendon 1cm below the suture entry point. Secure this second suture with a clamp.

Take a new suture. Place the third suture (ethibond 2, or ticron 5) from outside-in starting at the level of the second suture and pass it through the subscapularis tendon at the bony-tendinous junction. Pass through the 3rd hole of the prosthetic head (starting to count from inferiorly) at the anterior side of the humeral head from outside-in. Pass through the 2nd hole of the prosthetic head from inside-out and continue to pass the suture from inside-out through the subscapularis tendon 1cm below its entry point. Secure this third suture with a clamp.

Take a new suture. For the fourth suture, repeat the same through the 2nd and 1st hole of the humeral head. Secure it with a clamp.

Take a new suture. For the fifth suture (ethibond 2, or ticron 5), we start from outside-in at level of the first suture point of the supraspinatus tendon (suture one) at the bony-tendinous junction. Pass through the 5th hole of the prosthetic head (starting to count from antero-inferiorly) at the anterior side of the humeral head from outside-in. Pass through the 6th hole of the prosthetic head from inside-out and continue to pass the suture from inside-out through the supraspinatus tendon 1cm behind its entry point. Secure this suture with a clamp.

Take a new suture. Place the sixth suture (ethibond 2, or ticron 5) from outside-in at the entry point of the fifth suture through the supraspinatus tendon at the bony-tendinous junction. Pass through the 6th hole of the prosthetic head from inside-out and continue to pass the suture from inside-out through the supraspinatus tendon 1cm below its entry point. Secure this sixth suture with a clamp.

Take a new suture. Place the seventh suture (ethibond 2, or ticron 5) from outside-in starting at the level of the last suture through the supraspinatus tendon at the bony-tendinous junction. Pass through the 7th hole of the prosthetic head from inside-out and continue to pass the suture from inside-out through the infraspinatus tendon 1cm below its entry point. Secure this suture with a clamp.
Continue this procedure until you have passed sutures through the whole of the rotator cuff at its bony transition at the rim of the prosthetic head. The reason why different sutures go through the same hole is to provide enough stability in case a suture should cut out during final fixation. The holes in the rim are smoothened as much as possible but cut outs can still occur occasionally. Reduce the head in the glenoid fossa while pulling the sutures around it like a parachute. Make sure no aberrant tension or torsion is created on the rotator cuff when the sutures are tight. If so, replace the incorrect suture(s) in a more anatomical position. By leaving the sutures long, you can easily extract the head from the glenoid and replace it while keeping the other sutures in place. If the tension to the rotator cuff seems acceptable proceed to the humeral reaming.

**Humeral reaming** is done with the provided reamers in the set. Three stem sizes are available. Reaming is performed in the standard 25° retroversion. After reaming to the appropriate size, a trial humeral stem can now be inserted. Now pull all the sutures softly around the humeral head and inspect the posterior offset thus spontaneously created. Now select the corresponding offset hole to fit the humeral stem. Three different holes are available. If required, you can fix the head temporarily on the humeral component with a screw through the humeral stem. **Make sure you don’t tighten the screw too much** as this might leave the head with a secure fixation on the trial stem. By holding the sutures fairly tight, stability can now be tested. Measurements are placed on the stem to determine the required height. Remember the desired level by counting the lines on the stem.

At this stage, also inspect the position of the tuberosities compared to the stem and estimate their ability for refixation. Drill two holes through the lateral humeral shaft at the required positions. Put ethibond 2 or Ticron 5 sutures through the holes and secure them with a clamp. If all seems to be as desired, remove the temporary fixation screw out of the humeral stem. Insert the same screw driver through the humeral hole to tap out the head. The trail stem can now be removed. Ask for the definite stem size corresponding to the trial stem. Only stems requiring the use of cement are available. A cement restrictor can be used to stop the cement going to deep. One pack of 40 grams is usually sufficient if a cement restrictor is used. Now free up the head by releasing the tension on all the sutures. The prosthetic head can now be moved high up.

**Technique 1:** Fix the head on the definitive humeral stem by using a screw through the stem into the head. By tightening the screw, the taper system will secure the head onto the stem. Please make sure the previously tested posterior offset is respected. Now remove the screw as it will interfere with the re-fixation of the tubercles. If desired, a suture can be placed through the anterior hole in the stem to later secure the tubercles. Now cement the stem in the tested position taking care of the retroversion. A specially designed guiding devise is available in the set. By putting a guide pin in the required retroversion hole in the stem holder, the retroversion can be determined. Due to the long sutures, loose in the humeral head, the stem and head can be inserted without interfering with the rotator cuff. Once the prosthesis is in place, secure all sutures with stable knots, starting with suture one. (The different colour) Then continue in alternating directions, one anterior, other posterior until full reconstruction of the rotator cuff is achieved. As you will see the rotator cuff becomes more and more mobile with each suture making it more easier to knot the next suture situated more distally. Now take bone graft from the resected humeral head and put it in the hollow prosthetic head. Due to secure fixation of the rotator cuff around the prosthetic head, it is unlikely they will migrate into the joint. Now one only needs to secure the tuberosities by the previously inserted sutures in the humerus and through the anterior hole in the stem. After extensive irrigation, the wound is closed in layers.
Technique 2: It is also possible to insert the stem before fixing the head on the humeral component. After insertion of a cement restrictor, the stem is inserted taking care of the retroversion. Now the head is placed onto the stem in the previously determined posterior offset. The head is now secured on the stem by using a screw from the hole in the humeral stem into the head. The taper system will secure the head onto the stem. The screw is removed not to interfere with tubercle reinsertion. Now, rotator cuff fixation, bone grafting and tubercle fixation are performed as described above. Closure is identical to a routine shoulder replacement.

Postoperative regime
The postoperative rehabilitation is equally important for the final outcome. A adduction sling (or abduction pillow if required for comfort) is recommended. Immediate passive mobilisation is imperative to avoid shoulder stiffness. Early active movements can be allowed (after 3-6 weeks) as traction on the tuberosities is minimized. The time of active mobilisation is equally depending on the patients’ comfort.

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