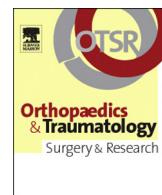




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## Review article

# Primary shoulder reverse arthroplasty: Surgical technique

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### ABSTRACT

Total reverse shoulder replacement is now a very common surgical procedure that has been shown to be effective in the treatment of rotator cuff tear arthropathies or massive rotator cuff tears with pseudo paralysis, even without arthritis. However, the survival curves of the oldest series decrease between 8 and 10 years after arthroplasty (events: implant survival, or worsening of clinical outcome) which explains why the indication for this type of arthroplasty is usually limited to patients over seventy. Moreover, details and technical modifications have been suggested to improve the surgical technique, the quality of fixation and the mechanical conditions of this non-anatomical prosthesis to improve clinical outcome and implant survival. Within the framework of primary surgery, excluding traumatic or revision surgery, the primary indications for this option are massive rotator cuff tears with (or without) osteoarthritis and primary osteoarthritis with rotator cuff tears and/or with severe glenoid wear and finally, rheumatoid arthritis. The purpose of this conference was to assess and describe the most important preoperative criteria and surgical conditions necessary for this procedure as well as specific technical details about the surgical procedure itself based on available options and options under evaluation such as the positioning of the glenoid component (lateralization, bone graft, orientation) and the association of muscle transfers.

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## 1. Introduction

After the rapid failure of models of constrained and/or reverse total shoulder arthroplasty (TSA) in the 1970's, the semi-constrained prosthesis developed by Grammont [1] was a real turning point in the treatment of painful functionally impotent shoulders with massive rotator cuff tears in elderly patients. This implant was original because it modified the functional center of rotation of the glenohumeral joint by adjusting several parameters: the center of rotation was now fixed on the glenoid bone and therefore medialized and lowered, thus lengthening the deltoid and raising its lever arm and moment of action. The principle was to optimize deltoid function to compensate for the functional deficiency of all or part of the rotator cuff. This optimization is caused by elongation of the muscle fibers resulting in improved performance [2,3]. Shear stress is replaced by compressive forces that improve the mechanical conditions at the bone/glenoid implant interface. The original Delta<sup>TM</sup> implant designed by Grammont has been modified, developed and transformed by numerous teams and manufacturers, confirming the continued interest in this concept thanks to the high quality clinical results in a population of elderly subjects who have often lost autonomy because of the condition of their shoulder(s). Numerous large published studies now exist with

significant follow-up [4,5], describing the clinical results, complications (secondary infection, instability) and radiographic outcome of this technique. Because of the nearly constant development of scapular notching [6,7] and more rarely glenoid "loosening", different teams have modified certain elements of the shape of the prosthesis itself or changed the implantation technique (humeral retroversion, vertical position, glenoid tilt...). A glenoid bone graft may be considered, not only to improve fixation in case of severe glenoid erosion, but also to improve the biomechanics of the arthroplasty [8]. Finally, associated soft tissue procedures, in particular muscle transfers, can be proposed to improve the functional outcome.

Because this is a conference on surgical technique, we will focus upon technical details including certain changes that have now been proposed to prevent complications and improve clinical results. Compatible muscle transfers will also be discussed.

We have excluded traumatic indications or revisions to limit ourselves to eccentric glenohumeral arthritis, pseudo-paralytic and upper migrated shoulders secondary to massive rotator cuff tears, and primary osteoarthritis associated with a severe rotator cuff tear or severe glenoid wear and finally certain rheumatoid arthropathies, as long as there is sufficient bone quality and moderate stiffness.

## 2. Preoperative evaluation, surgical planning

A short presentation of preoperative planning, which is an integral part of the surgical procedure, is necessary.

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## 2.1. Clinical evaluation

Besides the patient's general condition (operability), particular attention must be paid to the patient's loss of autonomy due to the condition of the shoulder to be operated on and other articular deficiencies. Indeed, this may be a contraindication to surgery (inability to get up from a seated position without the help of the upper limbs, permanent use of crutches).

The cervical-dorsal-scapular morphology should be analyzed to define the functional axis of the upper limb (especially in case of significant dorsal kyphosis modifying the axis of the scapula, which must be taken into account during placement of the prosthesis). Joint range of motion should be carefully evaluated, passive range of motion first, because as in all shoulder surgery, the quality of functional outcome depends mainly upon the quality of recovery of joint range of motion, and preoperative stiffness can only be partially recovered by surgery.

Deltoid function should be confirmed because it is indispensable for mobility of the prosthesis. Loss of active range of motion is one of the main indications for this procedure. At worst, the shoulder may be pseudo-paralytic. But the deficit may be partial, during elevation (El) persistent (+) or deficient (−) and/or during External Rotation (ER), with various combinations: El(+) / ER(+), El(+) / ER(−), El(−) / ER(+), El(−) / ER(−). All of these elements must be identified to plan an associated muscle transfer if necessary.

It is useful to summarize this functional assessment with specific scores [9] (Constant Score, Disability of the Arm, Shoulder and Hand, Subjective Shoulder Value, etc.) which will be the basis for assessment of future improvement.

## 2.2. Imaging evaluation

A standard radiographic assessment is performed including 3 AP views (internal, external and neutral rotation, a lateral Lamy view, an axillary lateral view or a Garth view); an AP view centered on the acromio-clavicular joint can also be added.

CT scan is very useful, and even indispensable. Arthrography is not systematically necessary because clinical results are generally enough to identify a massive rotator cuff tear and confirmation is not needed. A fairly extensive axial CT scan must be performed (of the entire scapula) to analyze the muscular fossa and evaluate the angle between the glenoid axis and the scapular blade. The CT scan must also include bone windows, muscle windows and frontal and sagittal reconstructions.

The following will be analyzed:

- severity of osteoporosis;
- stage of arthritis (especially glenohumeral and subacromial);
- severity of the cranial migration according to Hamada [10] (Fig. 1), and the vertical glenoid erosion according to Levigne and Favard [6] (Fig. 2);
- severity of the axial posterior erosion according to Walch and Badet [11] (Fig. 3);
- acromion status: thickness, fragmentation, spurs;
- muscular trophicity [12] in particular of the teres minor, which is essential for active external rotation.

MRI is less pertinent because it mainly explores the soft tissues while it is indispensable to obtain information on the bone structures.

## 3. Preoperative preparation

The preoperative preparation should follow the required recommendations for all arthroplasty procedures: preparation of

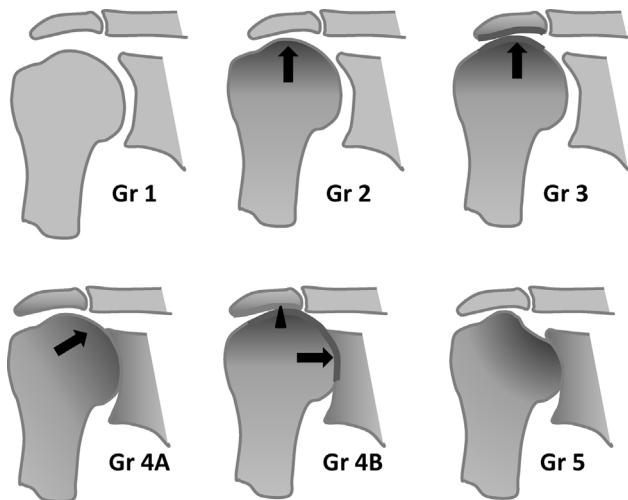


Fig. 1. Hamada classification [10].



Fig. 2. Coronal glenoid wear according to L. Favard [6].

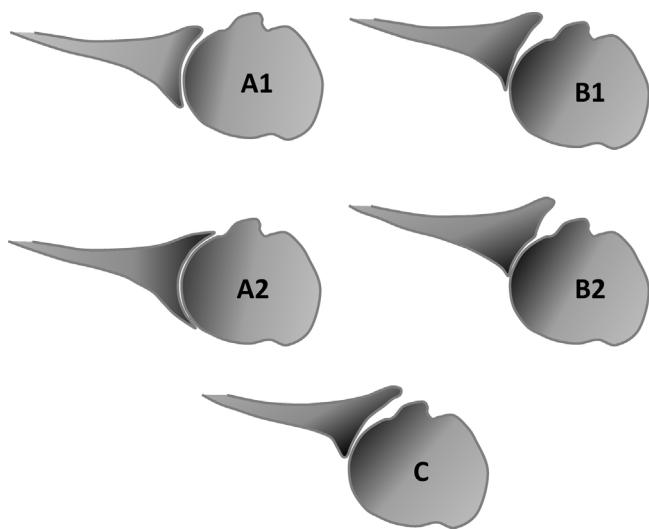


Fig. 3. Posterior glenoid wear according to G. Walch and R. Badet [11].

the skin surface, depilation, antibiotic prophylaxis, aseptic room, careful painting with Polyvidone® or Chlorhexidine®, which may be more effective against *Propionibacterium acnes*, a frequent source of postoperative infections of the shoulder.

### 3.1. Anesthesia

General anesthesia is usually used, associated with locoregional anesthesia, by interscalene brachial plexus block (except if there is a contraindication, especially respiratory deficiency).

### 3.2. Installation

Some specific precautions must be taken when placing the patient in the beach chair position and should be controlled by both



**Fig. 4.** The patient is installed in the “beach chair” position.

the anesthesia and surgical teams before the sterile surgical field is set up (*Fig. 4*).

In particular, satisfactory cerebral hemodynamics must be confirmed (by “reasonable” antiflexion of the trunk, lower limbs raised and venous contention), and there should be no compression of the upper limbs, no elongation of the sciatic nerve (flexed knees) or compression of the leg muscles. The head should be correctly attached in a neutral position, the eyeballs should be protected and should not be compressed. The thorax should be stabilized by a lateral block.

The upper limb being operated on should be completely free, so that it can be placed in retropulsion, external rotation and forced adduction. The shoulder must be free but the medial border of the scapula should rest on the table so that the scapula remains stable during preparation of the glenoid. All of the upper limb is included in the sterile surgical field and is on an armrest whose different possibilities of mobilization (which may be manual or pneumatic in more recent models) are checked.

The skin should be marked with references to bone landmarks and the path of the incision for the chosen surgical approach before setting up the sterile field.

#### 4. Intervention

Reverse shoulder arthroplasty includes 2 glenoid components: the Metaglene® which is usually attached with a central peg and screws to the scapula and the Glenosphere® which will be fixed to it. There may be 2 or 3 elements to the humeral component, depending on the model: the humeral joint insert (usually made of polyethylene) and an intramedullary metal humeral component: monoblock or modular (diaphyseal stem + metaphyseal component). Each element must be very carefully positioned.

##### 4.1. Surgical approaches

The surgical approach depends on the choice of the team, and is either an antero-superior trans-deltoid approach [13,14] to have a “straight ahead” approach to the glenoid, facilitated by the disappearance of the rotator cuff, but potentially damaging to the deltoid (which must absolutely be preserved) and not adapted to

stiffness; or a deltopectoral approach, which preserves the deltoid, with somewhat more difficult exposure of the glenoid but better exposure of the neck and pillar of the scapula (*Fig. 5*). The disadvantage is that the subscapularis must be cut increasing the risk of prosthetic instability (the debate is ongoing) [15].

##### 4.1.1. Trans-deltoid approaches

The skin is incised either along the axis of the deep dissection or by a rectilinear, sagittal “saber cut”, which is more cosmetic, making it possible to approach the deltoid muscle along the axis of its fibers, after pulling away a lateral skin flap (*Fig. 5A, B*). A split is performed between the middle and anterior deltoid parts in line with its fibers along the axis of an intramuscular raphe, which will make the sutures more stable at the end of the procedure. A proximal periosteal flap is carefully raised (with or without decortication) along the acromion. If the incision continues next to the acromio-clavicular (AC) joint to perform distal clavicular resection, deltoid detachment should be avoided because reinsertion in a muscular zone is not reliable. Stay sutures are placed to avoid muscle tears during placement of the retractors. The humeral head is exposed, usually directly through the rotator cuff tear.

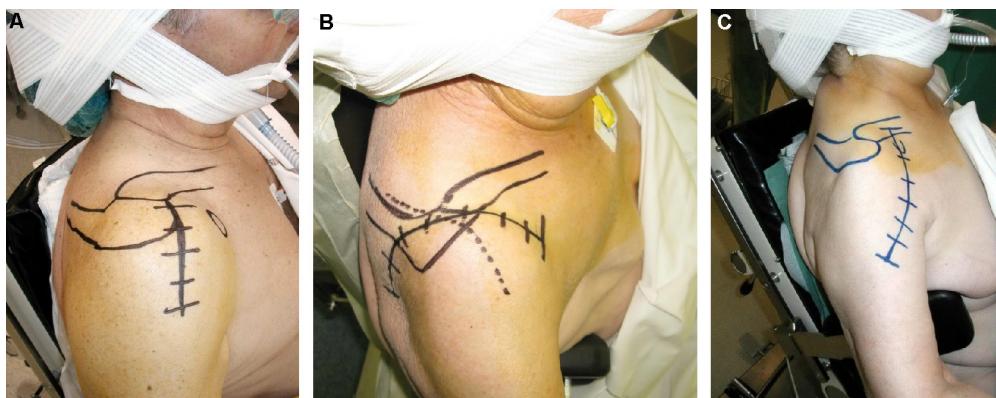
##### 4.1.2. The deltopectoral approach

This is the “royal” approach to the shoulder. It is not different from the classical description: dissection from the coracoid process to the anterior deltoid groove, while adapting the direction to follow Langer’s skin tension lines and moving slightly outwards so that the cephalic vein is always medial (*Fig. 5C*). The vein is usually mobilized laterally but sometimes medially if there is too much traction on its superior end. At this point, an autostatic retractor is used, stretching the clavicular-coracoid-axillary fascia which is opened vertically for medial exposure of the coracobrachialis conjoined tendon and the humeral head in the deep dissection, which is usually bare in this context.

##### 4.2. Surgical procedure

###### 4.2.1. Exploration of the rotator cuff and the humeral head

Identifiable elements of the rotator cuff must be precisely assessed: the biceps, which is often torn or degenerative and which



**Fig. 5.** Surgical approaches. A. Straight trans-deltoid incision. B. So-called “saber -cut incision” with inside trans-deltoid separation (dotted line). C. Deltpectoral approach.

must be systematically cut (with or without tenodesis) and the subscapularis which will be completely preserved or partially cut if the anterolateral approach is used. On the other hand, it should be cut laterally if the deltopectoral approach is used (with stay sutures on the medial part for later reinsertion). An osteotomy of the lesser tuberosity is not adapted to the humeral cut of this type of prosthesis (risk of metaphyseal fragility).

#### 4.2.2. Dislocation of the humeral head

Whatever the approach, dislocation of the humeral head is obtained by a combination of adduction, external rotation and retropulsion maneuvers, while applying pressure on the elbow from below to above (Fig. 6). The posterior rotator cuff is then checked, in particular the remains of the infraspinatus and the insertion of the teres minor.

#### 4.2.3. Humeral head resection

Humeral head resection is performed using a cutting guide that is specific to each prosthesis and may be different depending upon the surgical approach but is always based on acentro-medullary guide. The extent of retroversion is chosen by the surgeon, usually in reference to the axis of the forearm with the elbow flexed at 90° (Fig. 7A) (sometimes in reference to the axis of the humeral epicondyles). Grammont himself and several studies have confirmed this [16,17], recommended slight retroversion to try to preserve correct internal rotation. This is a functional sector where range of motion is often reduced, with disturbing functional consequences

such as difficulties in perineal hygiene. Nevertheless, if retroversion is to be limited, 2 other elements must be dealt with:

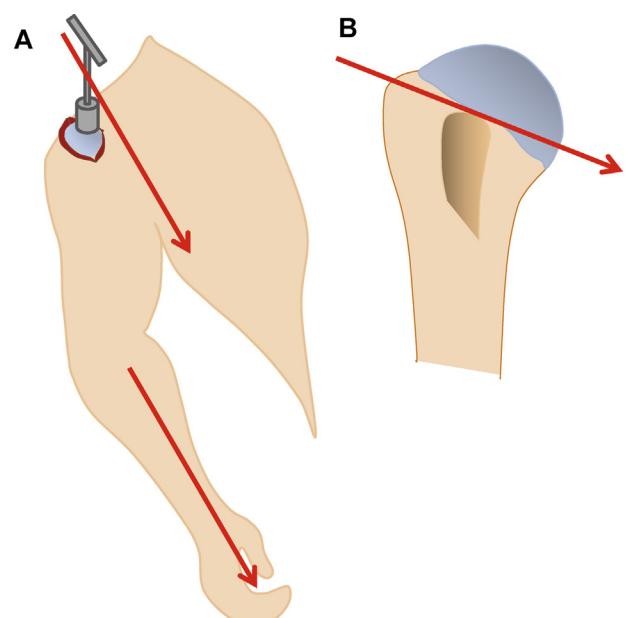
- first, the risk of anterior instability;
- and also, except for modular prostheses (Xtend™, Depuy), possible weakening of the antero-medial metaphysis if the chosen retroversion is too different from anatomical humeral retroversion; this can create less stable fixation of the implant, especially if it is uncemented. Ten degrees of retroversion is the most frequently accepted compromise.

Resection is performed slightly below the top of the greater tuberosity (Fig. 7B). It is usually more proximal with a deltopectoral approach (to limit the risk of instability) than with a superior approach (to see the glenoid).

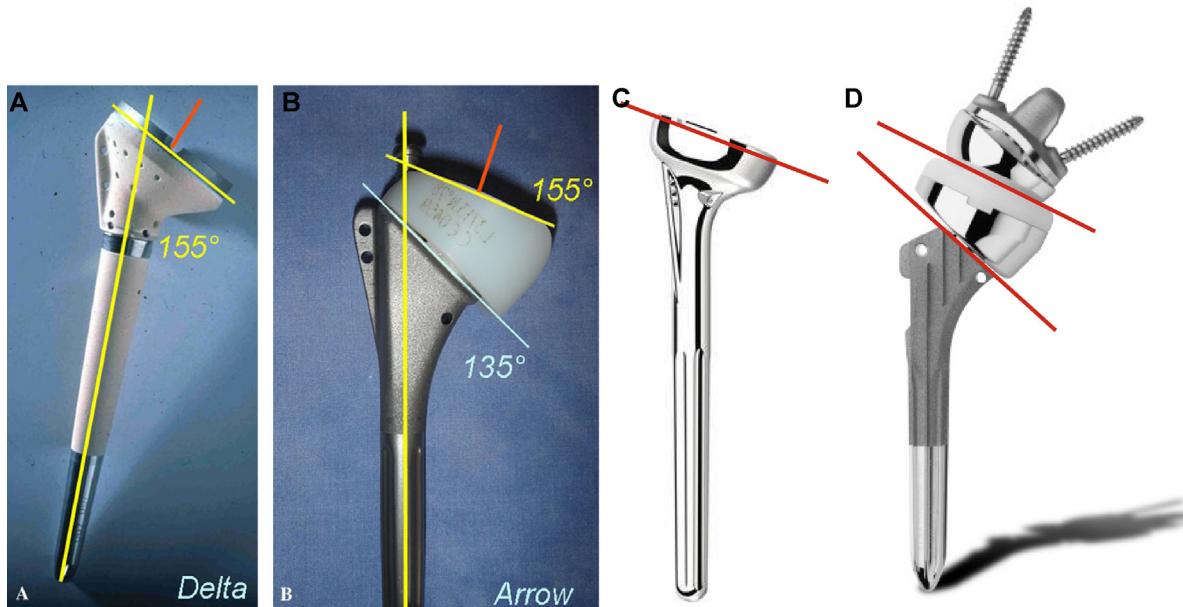
In most systems, the angle of the humeral cut (Depuy, Tornier) is more horizontal than the anatomical neck (145 to 155°). Certain manufacturers have chosen a more vertical cut to obtain a so-called universal prosthesis, which can be converted into an anatomical prosthesis. Horizontalization of the angle of the prosthesis is then obtained by the metaphyseal element or the polyethylene insert (FH, DJO, Exatech) [18] (Fig. 8).



**Fig. 6.** Antero-superior exposure of a “bare” humeral head through a trans-deltoid antero-superior approach.



**Fig. 7.** A. Control of the humeral retroversion according to the axis of the forearm. B. Level of the humeral cut.



**Fig. 8.** Comparison of the cut angle. A. Delta III™ Prosthesis – Depuy. B. Arrow™ Prosthesis – FH according to Valenti [18]. C. Delta Xtend™ Prosthesis – Depuy. D. Anatomical Reverse™ Prosthesis – Zimmer.

At this stage, either the humeral preparation is continued or as we prefer, a protector is placed on the bone cut to prevent it from being deformed by the pressure of the retractors while the glenoid is being prepared; these changes are even more marked if the metaphyseal region has already been prepared, reducing the area of bone that the retractor can press upon. The risk can be reduced by placing a trial prosthesis which provides rigid support to and protects the metaphysis, but which sometimes has several millimetres of superior overhang making it difficult to lower the humerus and expose the glenoid.

#### 4.2.4. Glenoid preparation

**4.2.4.1. Exposure of the piriform articular surface.** Exposure (Fig. 9) of the piriform articular surface requires complete excision of the glenoid labrum with an electric scalpel. An extensive circumferential periglenoid capsulotomy is then performed. Most of the

cartilage can be removed with a rugine and curette before using specific reamers. Special attention must be paid to identifying the base of the coracoid process above and the axis of the pillar of the scapula below. This is usually done by palpation or with an instrument but not visually to avoid extensive sectioning. Any inferior glenoid osteophytes should be carefully removed with a rongeur to expose the inferior glenoid edge. The axis from the coracoid process to the inferior glenoid rim, which is slightly tilted from above to below and back to front can be marked with an electrosurgical pencil as suggested by Grammont.

The surface of the glenoid must be fully exposed and accessible for drilling and reaming. The forked Trouilloud retractor, which presses on the inferior glenoid rim and therefore on the pillar of the scapula is perfectly well adapted for this. Other retractors such as the Kölbel, Hohmann or Fukuda retractors are also very helpful.

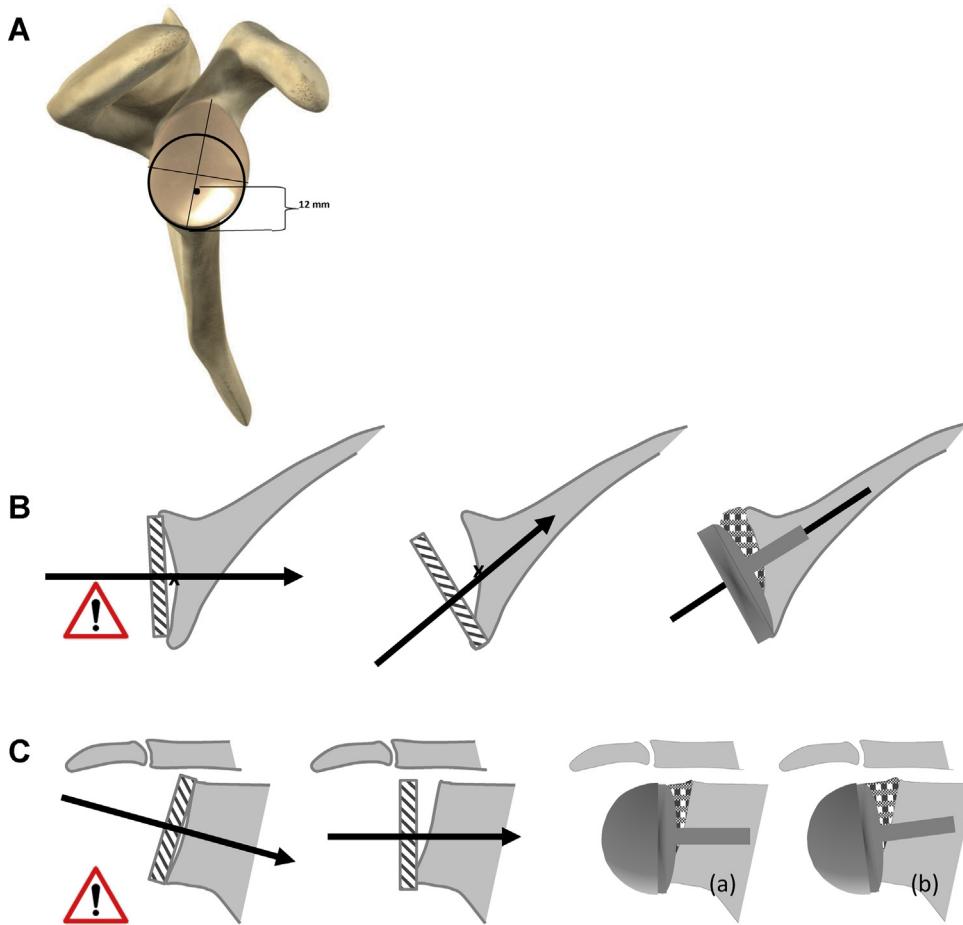
Most implants use peg fixation, usually central (in others the peg is above center, some have 2 pegs, or a vertical keel). It is not possible to describe all the options; only implantation of a metaglene with a central peg will be described in detail. Nevertheless, certain details of other techniques will be mentioned.

**4.2.4.2. The direction of glenoid reaming.** The direction of glenoid reaming (Fig. 10), which corresponds to the direction of the future central peg of the metaglene, requires integration of three-dimensional CT scan data:

- the center of glenoid reaming should be anticipated and planned including anticipation of an intercalated bone graft which is sometimes indispensable to compensate for bone loss, in particular postero-superior;
- vertical placement of the central K wire for glenoid reaming (Fig. 10A): studies by De Wilde [19,20] and Kelly [21] have clearly shown the importance of downward excentration of the glenoid component (glenosphere®) which is fixed to the base-plate (metaglene®) (12 mm above the inferior rim for Kelly). There are two reasons; first anatomical, the peg is placed in the area where the bone is the thickest and also mechanical interest so the inferior pole of the glenosphere can be placed under the neck of the scapula, while trying to obtain a final total inferior overlap of 3 to 4 mm. A specific guide whose lower rim is flush



**Fig. 9.** Glenoid exposure through a supero lateral approach (right shoulder).



**Fig. 10.** A. Vertical placement of the K wire for the glenoid reamer. B. In case of severe posterior erosion, the K wire is placed a little more anteriorly for asymmetrical reaming (more aggressive anteriorly) associated with a posterior bone graft. C. Position of the K wire in case of severe superior erosion. With superior bone graft (a), with bone graft and inferior tilt of the glenoid prosthesis (b).

with the glenoid one, makes it possible to place the drill bit or the K wire guide pin in a good place. It will serve as a reference for the later steps, when using cannulated reamers and drills. On the horizontal plane from front to back, compensation for significant posterior erosion should be anticipated (Fig. 10B):

- a median entry point can be chosen in case of a glenoid that is not deformed,
- in case of severe posterior erosion, a more anterior entry point is better. The chosen trajectory should correct, at least partially, posterior erosion by asymmetric reaming that is more significant anteriorly than posteriorly;
- superior tilt of the prosthesis should be avoided (Fig. 10C) and certain authors [22] even advise inferior tilt to limit the risk of notching. Some specific guides are designed to give this orientation to the central guide pin. Asymmetric reaming (more at the base) helps distribute compressive forces at the bone/baseplate interface. Nevertheless, it weakens the most solid area of bone at the glenoid/scapular pillar interface and reduces the length of the scapular neck. The interest of this inferior tilt is controversial [19,23–26].

Moreover, it is essential to make sure that there is contact with bone all along the tunnel and to measure its length (length of a K wire inserted to the end of the bone tunnel) to confirm that there will be sufficient bone-peg contact and length.

**4.2.4.3. The glenoid.** The glenoid is then scraped with specific resurfacing reamers. Reaming is often curved [27], and should be

thorough but not excessive to preserve solid subchondral bone. Any peripheral bone remains that could prevent later fixation of the glenosphere are carefully removed (with a specific peripheral scraper). The central peg is then prepared if this was not done before reaming and the baseplate is implanted.

**4.2.4.4. Impaction of the metaglene.** Impaction of the metaglene is performed either directly without or with a cancellous bone graft to increase the contact surface between the bone and the hydroxyapatite (HA) surface of the component, or a structural bone graft to correct severe erosion (Fig. 10C), or even an actual cylinder of bone described by Boileau in the “BIO-RSA technique” [8]; the goal is to lateralize the center of rotation of the prosthesis by creating a scapula with a long neck to reduce the risk of notching and improve rotation while maintaining the centre of rotation in the bone-prosthesis interface (once the graft is consolidated). In both cases of structural bone grafts, the central peg must be long enough to be anchored in native bone. Other implants [18,28] (FH, DJO) lateralize the center of rotation by the design of the prosthesis itself to reduce the risk of notching and improve rotation but also potentially increase shear stresses at the bone-prosthesis interface and thus the risk of loosening.

**4.2.4.5. Final attachment of the baseplate.** Final attachment of the baseplate is obtained by screw fixation (2–4 depending on the model). Drilling of each hole is motorized with in and out movements to feel the resistance and to know when the cortex has been perforated. The goal is to implant screws as long as possible

and to obtain stable fixation. Grammont described the principle of divergence of the inferior and superior screws with alternate tightening of each to ensure balanced compression of the metaglene in the prepared bone. Others prefer to obtain primary compression with anterior and posterior "straight ahead" screws. We prefer the former technique, especially since the quality of attachment to inferior and superior bone is much better. The first inferior screw trajectory is aimed slightly downwards into the scapular pillar; the second superior screw trajectory is aimed upwards in the direction of the coracoid process. Fixation can then be completed (depending on the system) by anterior and posterior screws. Certain designs (Mathys) have eliminated the inferior screw to prevent possible contact with the humeral component in case of deep notch. Various locking screw fixation systems now exist, which are especially recommended for superior and inferior screws.

The trial glenosphere (or even the final implant) can now be implanted. However, it is often preferable to prepare the humeral component at this point while keeping enough space to work in and to prevent scratching of the glenosphere.

#### 4.2.5. Preparation of the humerus

Two types of reamers are needed, one for the medullary canal and the other for the metaphyseal zone. The chosen degree of retroversion will be carefully preserved during preparation of the humerus. The size of the metaphyseal element will be chosen to adapt to the anatomy of the patient and to preserve as much bone stock as possible.

#### 4.2.6. Placement of the trial components and testing

If the shoulder is somewhat tight, the glenosphere should be placed first to "take advantage" of the space created in the humeral metaphysis to tilt the glenosphere onto the metaglene.

The diameter of the glenosphere (36 to 42 mm depending on the manufacturers) should be large enough to keep the glenosphere away from the pillar of the scapula below, in front and behind, so that it is not centered on the neck of the scapula. Nevertheless, it is still necessary to adapt to the patient's morphotype, making sure that the humeral component can move freely around the glenosphere, with no superior impingement against the acromion or antero-medial impingement with the coracoid process.

The humerus is again dislocated upwards and outwards taking care not to entrap the medial part of the metaphysis under the glenosphere.

The trial humeral component is then positioned and the prosthesis is reduced. The height of the metaphyseal element and/or the polyethylene insert is chosen by careful testing of muscular tension: deltoid in particular, but also of the coraco-biceps conjoined tendon, or even the triceps. Nevertheless, there are no objective or absolute criteria for this evaluation, which is also dependent upon the amount of curarization. Joint stability is confirmed by the absence of axial pistoning with the arm along the body, and by implant stability in all directions. It is also important to check the absence of impingement in particular inferior or posterior during adduction and external rotation of the arm. Additional humeral resection may be decided in case of excessive tension and difficult reduction which can lead to a risk of stress fracture of the scapular spine.

#### 4.2.6.1. Specificities of certain implants.

**4.2.6.1.1. Inserts.** Different inserts are available from different manufacturers with 2 different goals:

- they may be deeper (more constrained) (Tornier, Djo, Zimmer...) with better stability but with an increased risk of medial impingement against the scapular pillar, or on the contrary less deep

(Depuy) which limits internal impingement but with a theoretical risk of reduced stability;

- or with a more constrained insert (FH) with a medial notch to avoid contact with the pillar.

In addition, most of the designs on the market make it possible to combine different sized humeral epiphysis and glenosphere elements, while the exterior diameters of the humeral inserts are all the same (for example a 38 mm glenosphere, a 42 mm humeral epiphysis and 38 mm PE insert). The absolute rule is that the size of the glenosphere and the insert must be the same.

**4.2.6.1.2. Glenosphere.** The center of the glenosphere can be lowered during centering of the glenoid reaming. Moreover, the glenosphere itself can also be changed by using an eccentric design, which is available from numerous manufacturers. The exact placement of this design overlapping the inferior glenoid edge can be chosen during testing (usually inferior or postero-inferior).

After early failures with peripheral screwing, fixation of the glenosphere on the metaglene is now obtained with a morsel taper, after prior axial screwing, or with direct impaction.

**4.2.6.1.3. Inversion of the bearing couple.** Certain manufacturers (Mathys, Lima) have opted for a PE glenosphere and a metal humeral insert to limit production of debris from erosion. The implantation of these systems does not differ from others.

#### 4.2.7. Reduction

Once the components have been chosen, they are implanted beginning with the glenosphere. The final humeral component is fixed, whether it is monoblock or pre-assembled, with its diaphyseal component and its epiphysio-metaphyseal element. Uncemented (with HAP surface) and cemented versions are usually available. The common cementing techniques are used: cement restrictor, irrigating, drying and draining. An antibiotic cement should be used, in accordance with existing recommendations.

#### 4.2.8. Closure, immobilization and postoperative recommendations

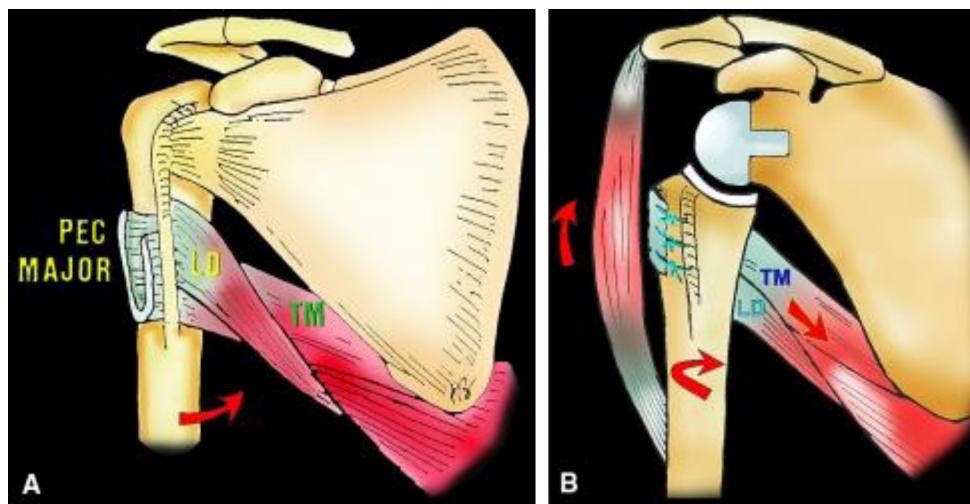
The incision is closed on a Redon drain (located in the sub-acromial space). Special care is taken when closing the deltoid during a supero-lateral approach (with trans-osseous sutures in the acromion) or when suturing the subscapularis during a deltopectoral approach. Immobilization is obtained either by an arm-to-chest sling (so-called Dujarrier sling and swathe) or if there are associated procedures such as a muscle transfer, on a pillow in slight abduction or in neutral or external rotation.

Early passive mobilization is usually possible. The patient is advised to avoid positions that would strain the operated shoulder.

#### 4.3. Associated procedures

Depending upon associated lesions, arthroplastic resection of the AC joint or tenotomy of the biceps with or without tenodesis may be necessary.

Tendon transfers may be indicated in case of complete loss of external rotation, which cannot be compensated by the prosthesis alone. Gerber [29] was the first to describe the latissimus dorsi transfer in massive postero-superior rotator cuff tears and adapted the technique so that it could be associated with reverse arthroplasties. He used a second posterior approach to ensure postero-superior fixation of the tendon with no other major changes in the postoperative protocol: short immobilization in external rotation. Boileau, on the other hand [30] (Fig. 11), proposed transfer of the conjoined teres major and latissimus dorsi



**Fig. 11.** Associated teres major and latissimus dorsi transfer through a deltopectoral approach.

P. Boileau [30].

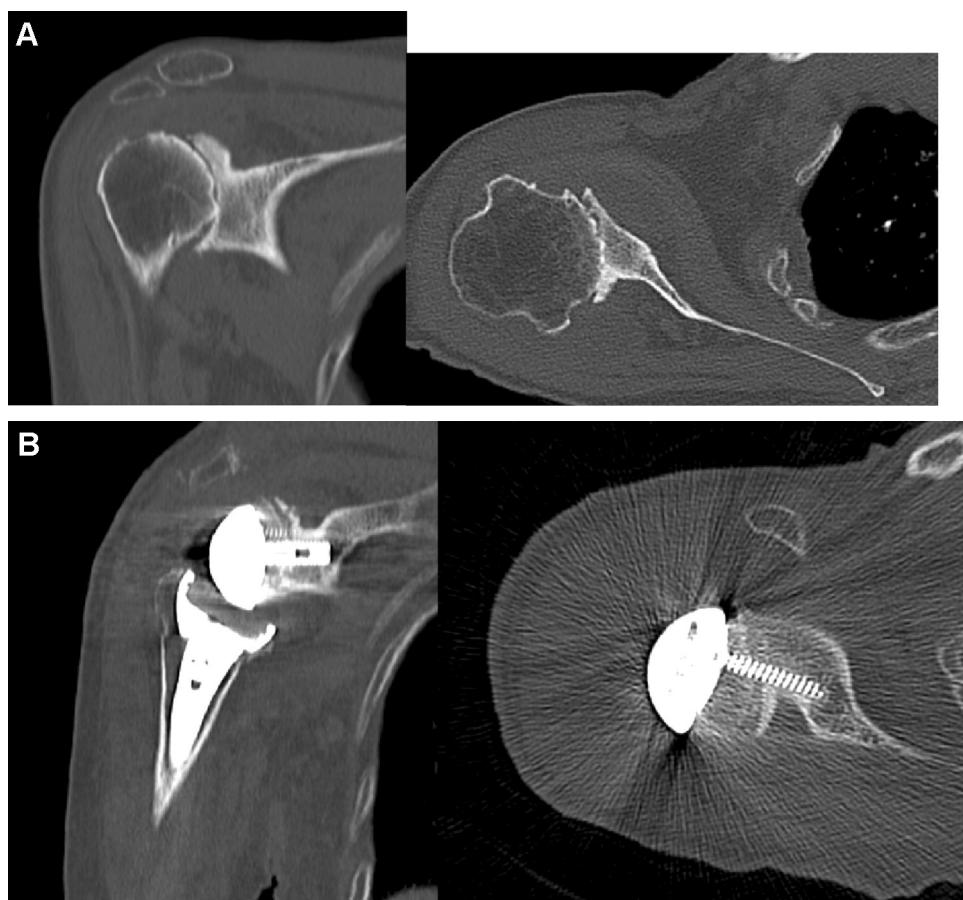
using the same deltopectoral approach (L'Episcopo technique): the tendons encircle the humerus and their fixation is located at the same height as their insertion site, but outside the bicipital groove. The postoperative course is longer with immobilization in external rotation for 6 weeks followed by 3 weeks of rehabilitation for internal rotation. Nevertheless, because of the poor tolerance of a residual hornblower's sign, even if there is no pain and good anterior elevation, these transfers could be very useful and should be discussed depending on the patient's motivation and general condition.

## 5. Conclusion

Because of the high quality results and improved functional outcome obtained with Grammont's semi-constrained reverse shoulder arthroplasty, this treatment option still deserves careful attention to the implantation technique and continued research to optimize the procedure, as long as the initial mechanical principles of the technique are respected. Modern innovations of computer navigation or personalized instruments may make this procedure even more precise.



**Fig. 12.** A. Massive rotator cuff tear with antero-superior off center position of the humeral head. B. Postoperative outcome.



**Fig. 13.** A. Coronal and axial preoperative CT scan views of glenohumeral arthritis with E2-B1 glenoid erosion. B. Postoperative AP view and axial CT scan with prosthesis in place with posterior autogenous bone graft.

The indications for primary prosthesis, besides trauma, have already been described: primarily rotator cuff tear with upper migration of the humeral head (Fig. 12A, B). This can be extended to certain cases of primary glenohumeral osteoarthritis with severe glenoid wear depending on the possibility of setting a bone graft behind the metaglene (Fig. 13A, B).

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