MENTORS IN ORTHOPEDICS

HOW TO SUCCESS STEMLESS REVERSE SHOULDER ARTHROPLASTY BY FOCUSING ON HUMERUS BONE QUALITY: A RETROSPECTIVE ANALYSIS OF 86 SMR IMPLANTS WITH SURGICAL TIPS AND TRICKS

https://doi.org/10.71165/phcm-h9of

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SUMMARY

Background: Stemless total shoulder arthroplasty (TSA) utilizes epiphyseal-metaphyseal fixation rather than diaphyseal anchoring. While anatomical stemless designs are established, stemless reverse total shoulder arthroplasty (RTSA) remains subject to clinical skepticism regarding primary fixation stability and the risk of early humeral loosening in older populations with potentially compromised bone quality.

Objective: This article evaluates the clinical and radiographic outcomes of stemless RTSA, identifies specific surgical challenges, and outlines a standardized technical protocol to optimize metaphyseal fixation.

Key Points: A retrospective analysis of 86 stemless RTSA procedures (mean age 71.4 years) demonstrated significant improvements in ASES, Constant, and SSV scores at a minimum two-year follow-up. Radiographic analysis of 52 patients showed stable implants with minimal humeral lysis. However, four cases of early non-traumatic loosening occurred, attributed to inadequate bone stock assessment. Essential technical requirements include preoperative CT/MRI imaging, intraoperative "thumb press" testing of metaphyseal density, and bone-sparing humeral preparation. The protocol emphasizes maintaining a 2mm cancellous margin, avoiding cortical contact, and utilizing size-specific reaming or impaction based on bone quality. Stemless designs facilitate easier revision, reduce blood loss, and preserve bone stock for potential future interventions or fracture management.

Conclusion: Stemless RTSA provides functional outcomes comparable to stemmed designs when appropriate bone quality is present. Success necessitates rigorous intraoperative assessment of the humeral metaphysis and a low threshold for transitioning to stemmed implants if bone density is insufficient for primary stability.

KEYWORDS

Arthroplasty, Replacement, Shoulder; Shoulder Prosthesis; Joint Diseases; Bone Cements; Treatment Outcome

INTRODUCTION

What is a stemless total shoulder arthroplasty (TSA)? The definition derives from the relationship between the humeral component and the humeral anatomy: a stemless component has no fixation in the humeral diaphysis; instead it uses epiphyseal-metaphyseal fixation. An implant can have a stem, a short stem or no stem.

There is no doubting the enthusiasm for anatomical stemless TSA, as shown by the number of available implants and multitude of articles on the topic. In simple terms, an anatomic TSA places minimal constraints on the humeral component. Patients are relatively young, and arthrosis means dense bone stock allowing for a solid primary fixation.

The configuration is different for a reverse arthroplasty (RTSA), which is more constrained especially on the humeral component. Patients tend to be older with lesser quality bone stock, which can compromise the primary fixation. A specific complication is early humeral loosening.

Surgeons and manufacturers are therefore more sceptical or reluctant towards the idea of using stemless RTSA, although the first stemless RTSA, the T.E.S.S. (Zimmer Biomet)[1], was introduced in France in 2006. Since then, the Easytech (FX Solutions, 2013) [2] and SMR Stemless (Lima, 2014) (Fig. 1) have consolidated the interest in this bone-sparing method (both these implants are currently awaiting authorisation for the American market).

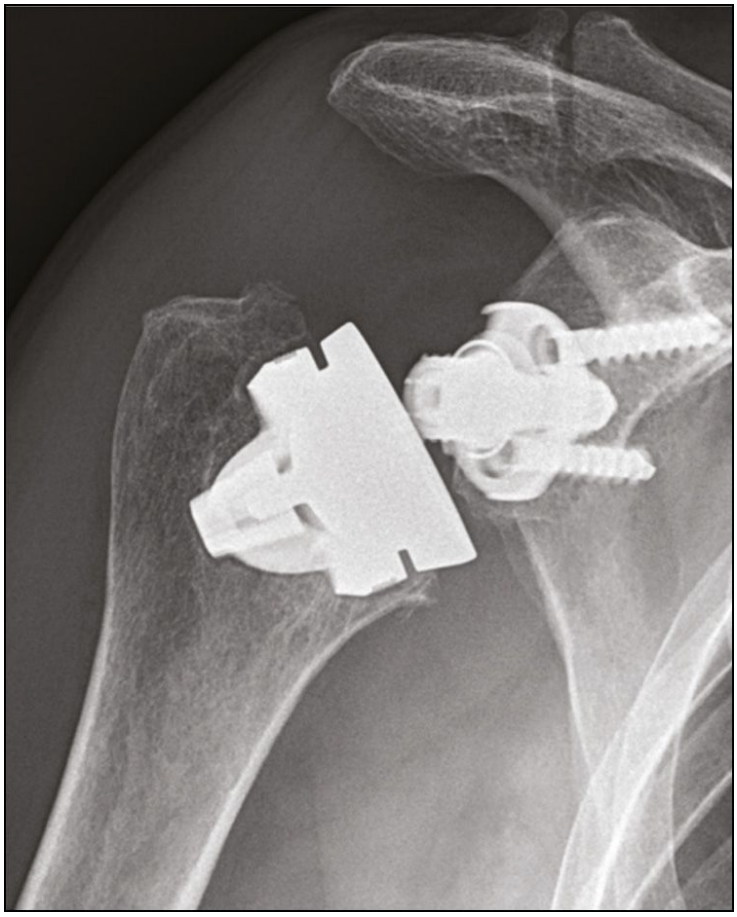

Figure 1: LIMA SMR stemless reverse system

Why use a stemless TSA?

- To preserve bone stock: young patients can benefit from a RTSA and revisions should be expected.[3] Surgical revision of a stemmed implant, whether cemented or cementless, is a tricky procedure with limited functional outcomes as it causes major damage to the bones, tendons and muscles, regardless of the surgeon's skill.
- In cases of a post-arthroplasty fracture: surgical revision is easier because the implant can be switched to a stemmed design, or an osteosynthesis plate placed beneath the implant.
- Contraindication to a stem: the presence of humeral osteosynthesis material, a former fracture with malunion and/or a dysmorphic humerus.
- Quicker and less blood loss: there is no need to prepare the humerus, which can be time-consuming in fragile patients, under general anaesthesia and semi-seated.
- Ease of exposure: the humerus is prepared along the metaphyseal axis instead of the diaphyseal axis with less trauma to the anterior deltoid.

What are the difficulties?

- It can be hard to evaluate bone stock during planning. Despite CT scans, MRIs and evident lesions (e.g. necrosis or cysts), there are no other methods for obtaining accurate information about metaphyseal bone density. In our experience, bone quality depends more on past medical history than on age and sex. It is important to consider any illnesses or treatments that can diminish bone stock, for example shoulder pseudoparalysis without osteoarthritis, cardiovascular disease such as infarction, chronic bronchitis and steroid use. There is not yet any firm evidence and a study is under way.
- The mechanical constraints exerted by the reverse implant and the upwards shearing force require a solid primary fixation to allow for early rehabilitation. Solid bone integration seems mainly to occur around the ring. There is poor integration around the fins and post, as we have found for the few cases we have had to remove a stemless implant (Fig. 2).

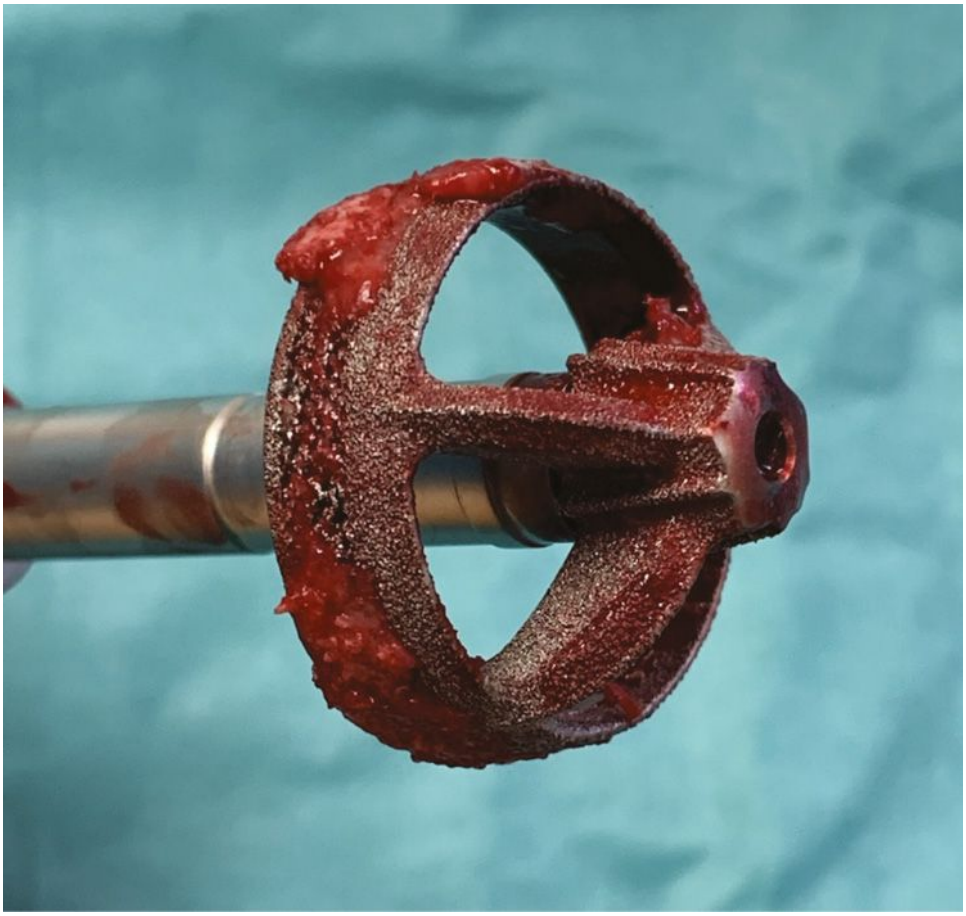

Figure 2: Osseointegration zone.

What are the particular considerations when performing a stemless TSA?

- Bone stock assessment: bone quality (e.g. necrosis, cysts, sepsis) should be assessed prior to surgery, using sliced images, along with a review of past medical history. However, the majority of the evaluation occurs in theatre during surgery using the thumb press test. This is a new but essential practice and habit: the density of the metaphyseal bone can be estimated by pressing firmly with the thumb. The results will determine the best surgical option.
- Bone-sparing: During surgery and especially when exposing the glenoid, it is crucial to minimize metaphyseal damage by means of good soft tissue release and good placement of the arms and retractors.
- Have a Plan B: Despite having planned for a stemless reverse arthroplasty, you also need to plan for a stemmed implant should the bone quality not be good enough or in case of any doubt.

SERIES ANALYSIS

We conducted a retrospective analysis in a continuous single-center series of 86 reverse stemless replacements for 86 patients, with a minimum follow-up of two years. The population comprised 44 women and 42 men, with an average age (on day of surgery) of 71.4 years (range 51–86).

34 patients were excluded

- 4 deaths

- 11 lost to follow-up, could not be contacted
- 13 refused to attend the appointment, but said their operated shoulder was doing well
- 1 dislocation
- 1 early post-traumatic detachment of the glenoid requiring surgical revision. Patient not reviewed but was doing well
- 4 humeral loosenings (Fig. 3).

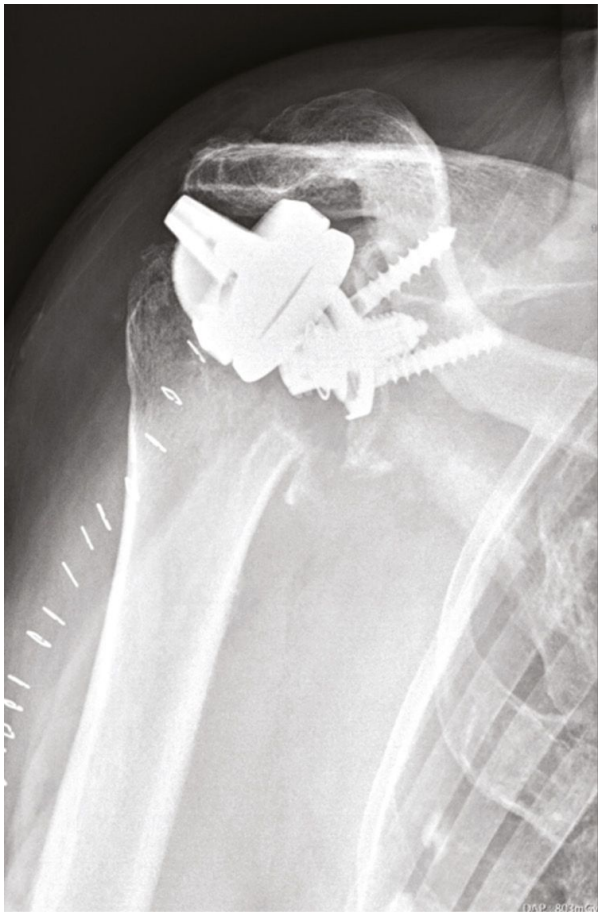

Figure 3: Non-traumatic loosening on day 2.

Evaluation included functional scores, complications and x-rays. We experienced certain difficulties when it came to reviewing patients who were often elderly, didn't want or were unable to travel, with little or no access to online self-assessment tools etc.

For all patients the Lima SMR implant had been used. This implant has a glenosphere (40mm or 44mm diameter) which comprises two-thirds of a non-eccentric polyethylene sphere. The humeral cut is made at 135° using a guide, and the metaphyseal insert (three thicknesses) is at an angle of 7°, which puts the CCD angle of the RTSA at 142°. We make our cuts with 20° retroversion.

Patients details, pre- and postoperative scores (ASES, SSV and Constant)

for the 52 patients with 52 reverse stemless arthroplasties are summarized in Table 1.

Average age at time of surgery	70.1 years (Range 51–86)
Average follow-up	51 months. (Range 24.7–85.5)
Preop SSV score:	33 ± 13 (Range 10–60)
Preop ASES score:	30 ± 10 (Range 10–58)
Preop Constant score (without strength assessment (max. 75):	22 ± 9 (range 2–47)
Postop SSV score:	79 ± 17 (Range 20–100)
Postoperative ASES score:	89 ± 14 (Range 38–100)
Postoperative Constant score (without strength assessment):	55 ± 13 (Range 11–71)
Forgotten shoulder:	45 (86.5%), not forgotten 7 (13.5%)

Box plot comparison of pre- and post OP ASES, Constant and SSV scores

are summarized in Figs. 4, 5 & 6

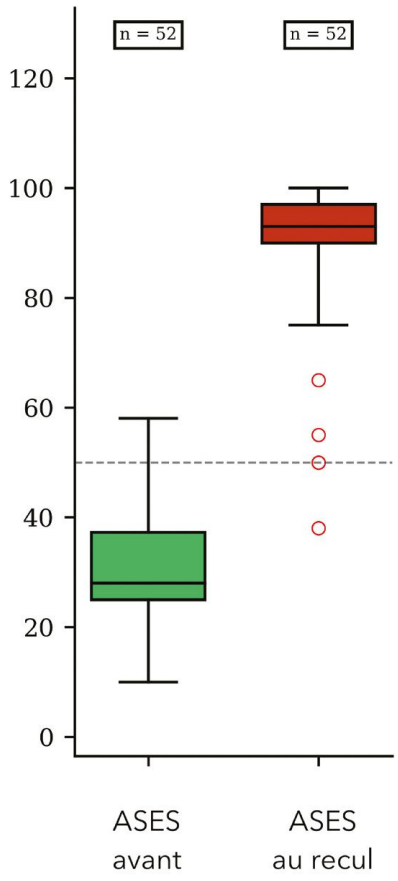

Figure 4: ASES Score - Before vs. At time of follow-up

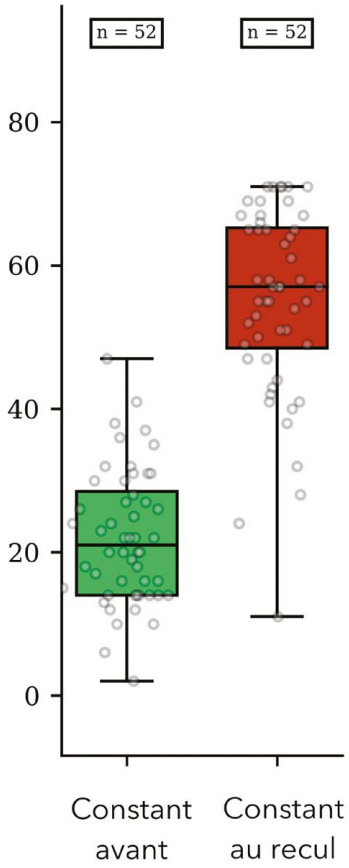

Figure 5: Constant Score - Before vs. At time of follow-up

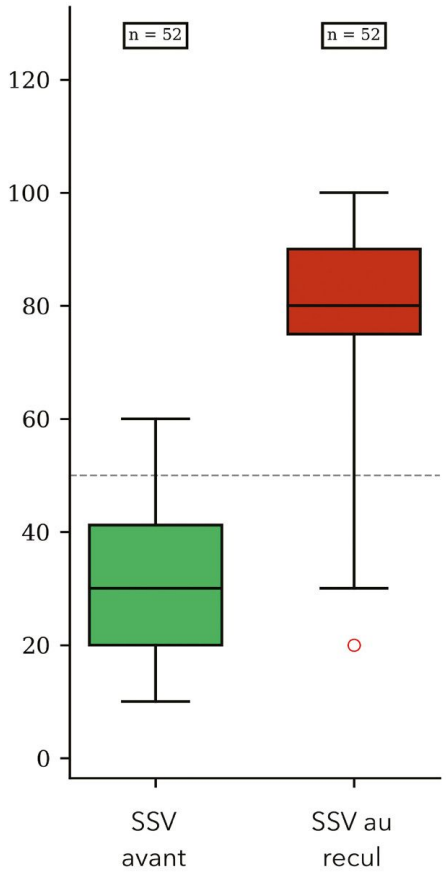

Figure 6: SSV Score - Before vs. At time of follow-up

Radiographic analysis

Radiographic analysis for the 52 usable x-rays are summarized in Table 2. Analysis based entirely on a frontal x-ray: position of glenoid implant, notching, humeral lysis (5 zones – see Figure 7)

Position of glenoid baseplate vs. lower rim of glenoid:	flush 49 (94%) high (4%) low 1(2%)
Notching in 6 cases (11.5%):	2x type 1 3x type 2 1x type 3
Lysis around the humeral metaphysis.	No 44 (84.6%) Yes 8 (15.4%)
Zonal analysis	Zone 1 and 2: 1 Zone 2 and 5: 1 Zone 4: 1 Zone 5: 5.

Table 2: radiographic analysis

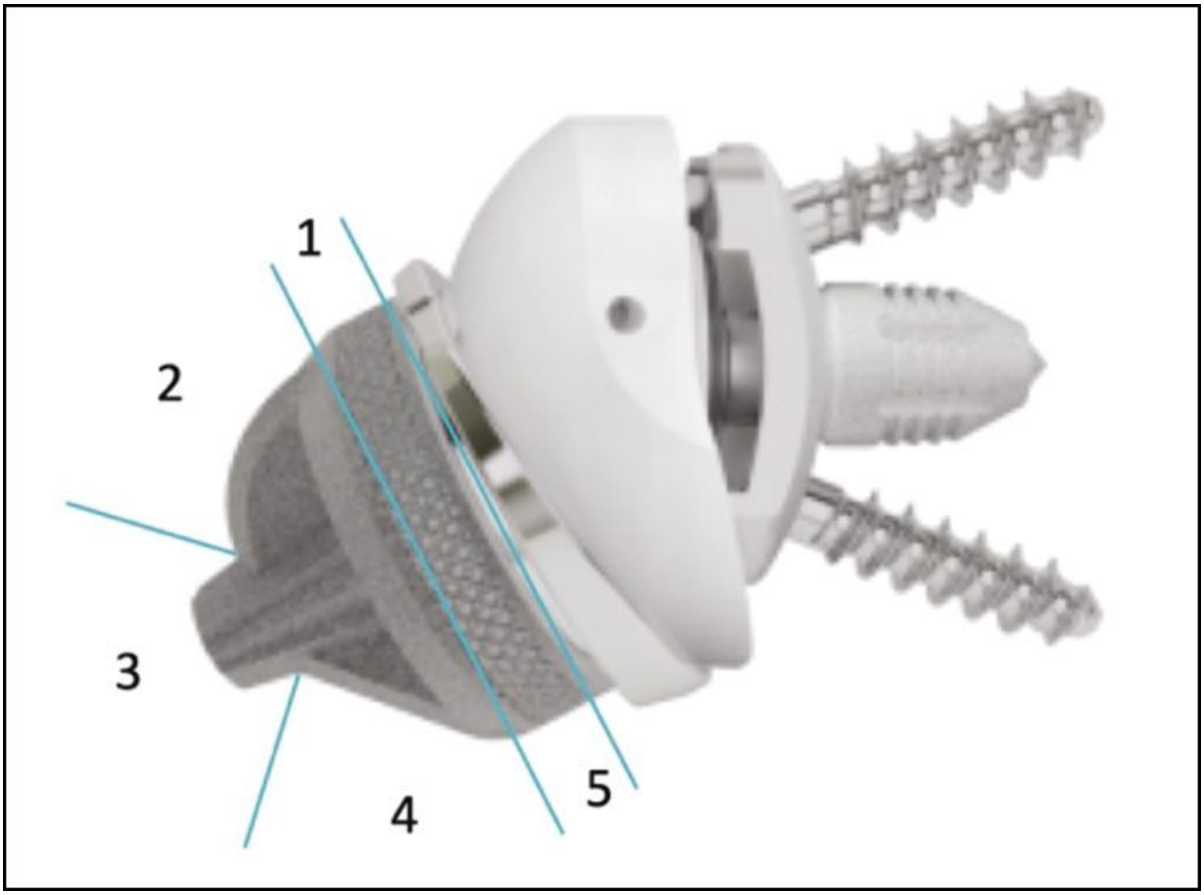

Figure 7: Lysis zones.

Non-specific complications (52 shoulders)

None 43

Stiffness with loss of passive range of motion 2

Undefined chronic pain 3

Reverse scapulohumeral rhythm 3

Fracture of the operated acromion 1

Statistical analysis

We used EasyMedStat to search for correlations between CCD angle, notching, glenoid baseplate position, functional scores and complications, but the effects were too weak for a statistical analysis. here was a significant improvement in all functional scores.

DISCUSSION

The outcomes of stemless anatomic TSA are proven to be equivalent to those of stemmed implants.[4],[5] Few articles have looked at the outcomes of stemless reverse SA, [6],[7] but the conclusions are the same: the improvement in shoulder function is as good as that achieved with stemmed designs.

However, there are many surgeons who believe that stemless RTSA carries a non-negligible risk of early loosening due to poor fixation in the metaphysis alone, leading to early revision. There is no doubt that using a stemless implant, especially with the reverse procedure, requires a change in habits because the surgeon must use the thumb test to check the quality of the bone stock. However, this simple method for assessing the bone means the procedure can then be adjusted accordingly based on established techniques and any necessary adaptations.

The four cases of non-traumatic early loosening were due to poor assessment of bone density and the use of a metaphyseal reamer that aggravated the loss of bone stock. Having continued to use this technique, we have so far performed over 250 stemless RTSA (May 2014–Dec 2021) with one single other recent case of loosening following a fall in the first two weeks. We would like to describe the technique for a stemless RTSA in more detail.

RULES FOR A SUCCESSFUL STEMLESS RTSA

There are a few key humerus-based principles for ensuring a successful implantation of a reverse (or anatomic) stemless system.

1. Planning and assessment

a. Imaging to produce a set of sliced images (CT or MRI) is essential (Fig. 8).

b. No obvious contraindication such as a large cyst or osteonecrosis creating a lack of metaphyseal bone.

c. Osteophytes requiring removal.

d. Previous fracture with humerus healed misaligned, to ensure the implant can be correctly positioned.

2. Set-up and approach

a. Patient set-up should be closer to dorsal decubitus, than semi-seated. This has two advantages - less constriction when dislocating the humeral head, and better cerebral perfusion (Fig. 9).

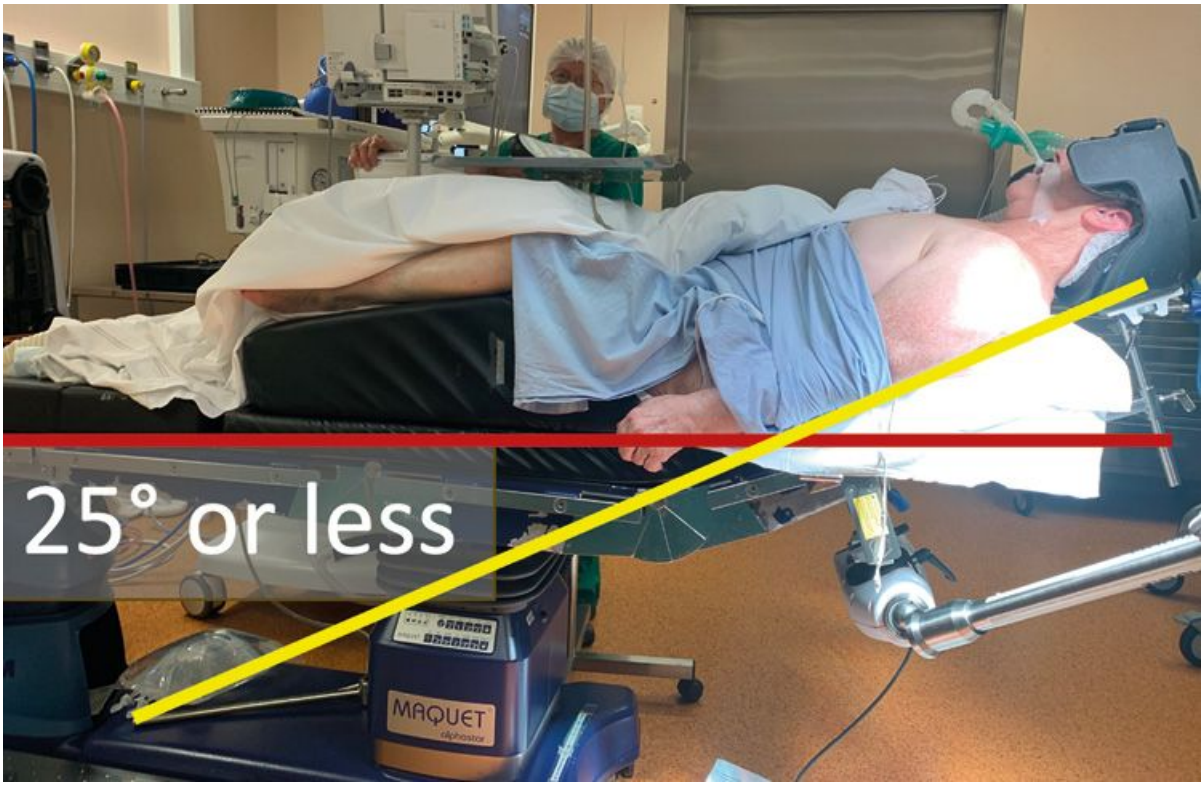

Figure 9: Patient set-up

b. A deltopectoral approach is best, because the smaller humeral cut spares more bone than the superolateral approach. In addition, the capsule can be released easily at the humeral neck and around the glenoid, releasing any soft tissue stresses and facilitating exposure.

c. The glenoid can be approached with less constraint on the humerus.

3. The subscapular opening should aim to spare bone stock, with two possible techniques:

a. Tenotomy in the zona alba (tendon-tendon)

b.Peel technique. The tendon is reinserted with a transosseous suture or onto bone anchors, which are easy to place thanks to the absence of a stem.

c. There is a third technique, a thin lesser tuberosity osteotomy, but it is risky and should be avoided.

4. Humeral cut

a. The cut must be sufficient to properly expose the glenoid without tension whilst at the same time sparing the metaphyseal bone.

b. The upper insertion of the subscapularis tendon can be used to guide the height of the cut. The cut certainly shouldn't go beyond this point and can even be smaller to preserve a little more of the bone (Fig. 10).

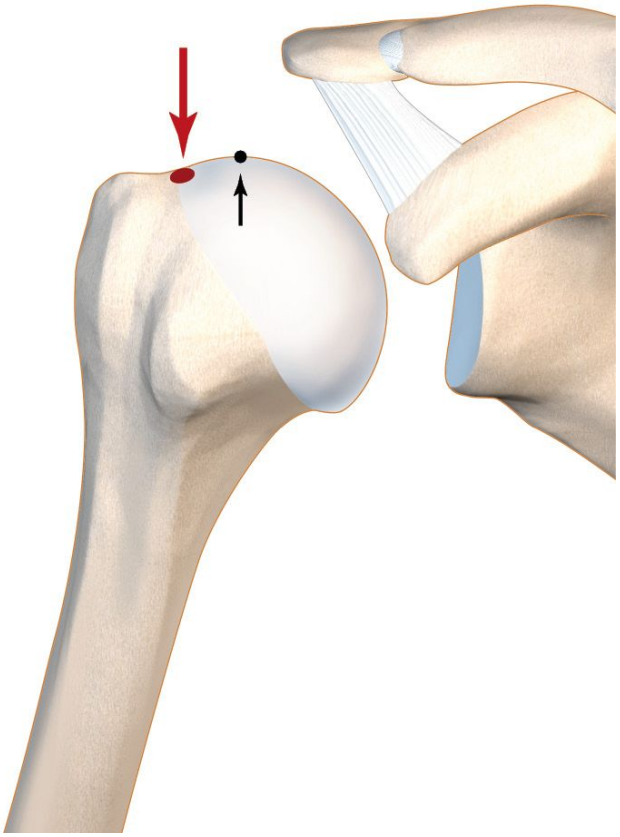

Figure 10: Humeral cut and subscapularis tendon

c. Using an intramedullary guide is advisable when first starting out, for ‘large’ shoulders and for difficult exposures. It has the advantage of ensuring the correct angle and retroversion (Fig. 11)

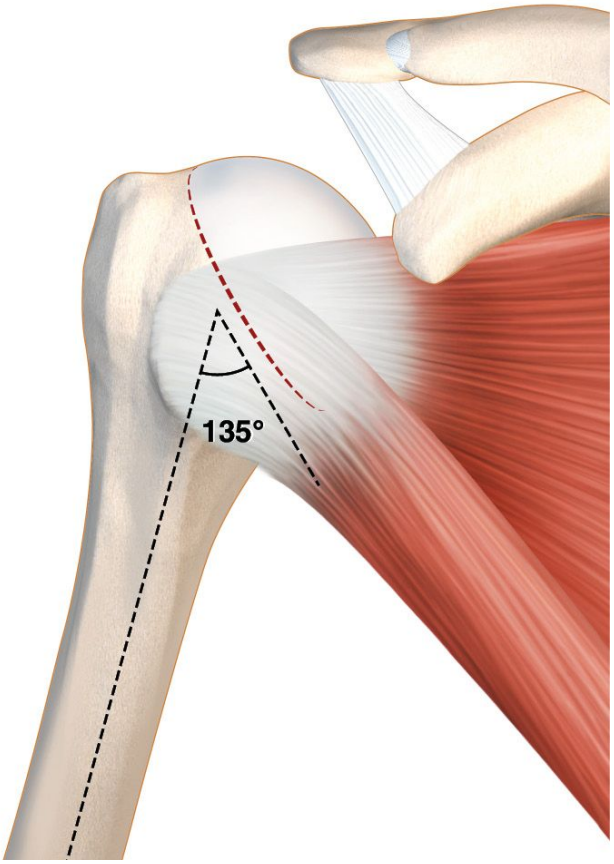

Figure 11: Insertion point for the intramedullary guide (red arrow)

d. Retroversion is typically 20°, but depending on the surgeon's preferences it can be adapted to the patient anatomy and retroversion. It is important to visualize the insertion of the infraspinatus tendon and cut close to the anatomic neck.

5. Bone quality assessment and thumb test

a. Essential

b. Not dependent on thumb size and ultimately depends very little on pressure: the bone quality is either good or bad.

c. Adjusting reamer, trial and implant size according to thumb test (Table 3)

HARD BONE	MODERATE BONE	ACCEPTABLE BONE	POOR BONE
Reaming size n	Reaming size n-1	No reaming - Impacting	Stem
Trial size n	Trial size n-1	Trial size n-1	
Implant size n	Implant size n	Implant size n	

Table 3: Adjusting reamer, trial and implant size according to thumb test

6. Implant diameter and size

a. The implant should never come in contact with the cortical bone due to the risk of fracture. There should be a cancellous margin around the implant of at least 2mm (Fig. 12).

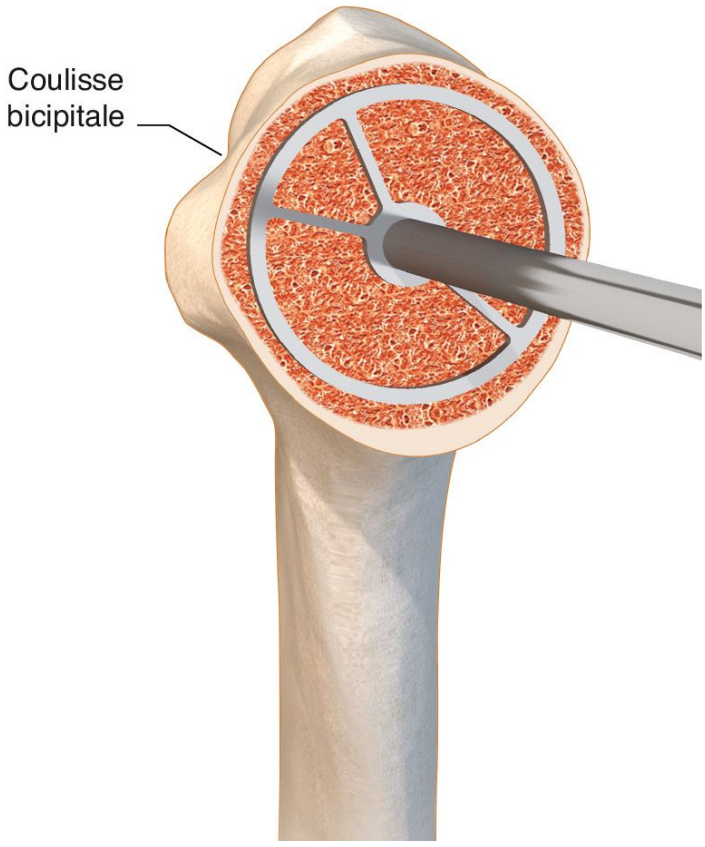

Figure 12: Implant size

b. The implant is held in place by its ring, which must therefore fit perfectly into the metaphysis. Make sure that the distal post is not touching the bone. (For the LIMA SMR, one solution is to ream for a long post but use a short post) (Fig. 13).

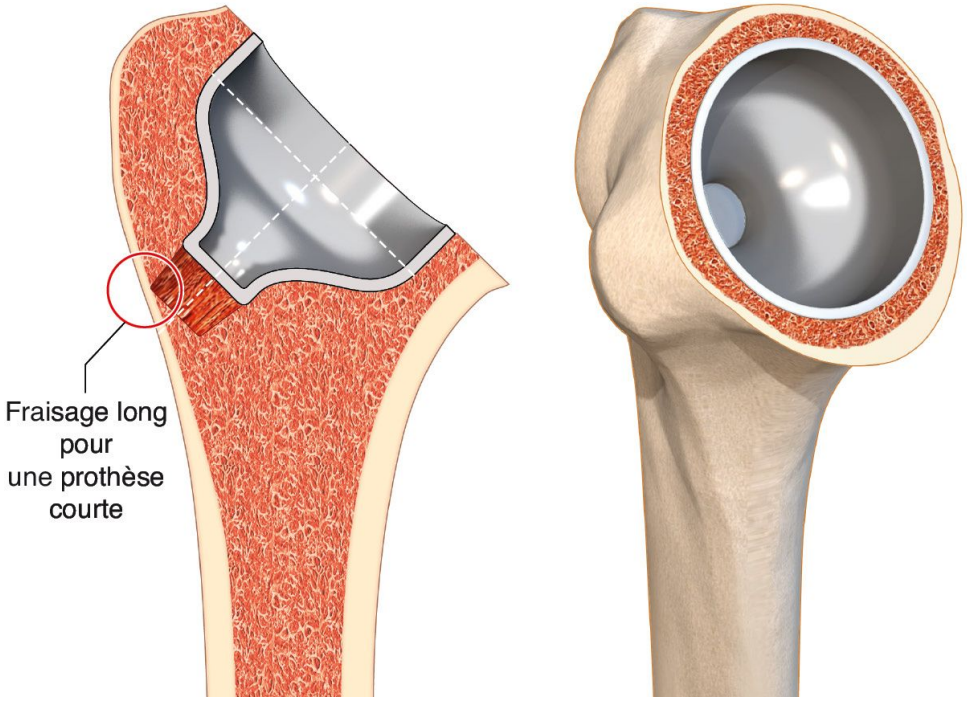

Figure 13: 'Long' reaming for a 'short' implant

c. If unsure between two sizes, select the smaller. The actual implant is always slightly larger than the trial implant.

7. Metaphysis preparation based on bone quality (Table 3)

HARD BONE	MODERATE BONE	ACCEPTABLE BONE	POOR BONE
Reaming size n	Reaming size n-1	No reaming - Impacting	Stem
Trial size n	Trial size n-1	Trial size n-1	
Implant size n	Implant size n	Implant size n	

Table 3: Adjusting reamer, trial and implant size according to thumb test

a. If the bone is hard and good quality, there is no need to alter the procedural steps, namely size-for-size reaming, implant of the trial component, followed by implant of the definitive component.

b. If the bone is not hard, use a reamer and trial component one size down to make sure the definitive component is securely fixed.

c. For surgeons experienced in stemless procedures, acceptable bone quality can be overcome by improving the bone stock with impaction, with no need for any reaming. Selecting a trial component one size down should be enough to create the marks and protect the humerus when inserting the glenoid construct.

d. If there is any doubt at all, switch to a cemented or cementless stemmed design.

8. Protect the humerus when inserting the glenoid component

a. The rigid retractor is placed behind the glenoid resting on the trial component, parallel to the humeral cut. Special guard plates can be placed on the cutting plane.

b. Start reaming the glenoid and checking that the reamer is not hitting the humerus or the retractor.

c. Once the glenosphere is in place, dislocation of the humerus 'around the glenosphere' should be effortless and without constraint.

9. Assessing fixation after final implant placement

Once the final implant is in place, hold the metaphyseal component between two fingers to test the fixation. In case of any doubt at all, stay on the side of caution and switch to a stemmed implant.

Stemless or stemmed, depending on surgeon preference:

Soft tissue release around the glenoid cavity will ensure better exposure and reduce the constraints by the retractors on the humerus (Fig. 14).

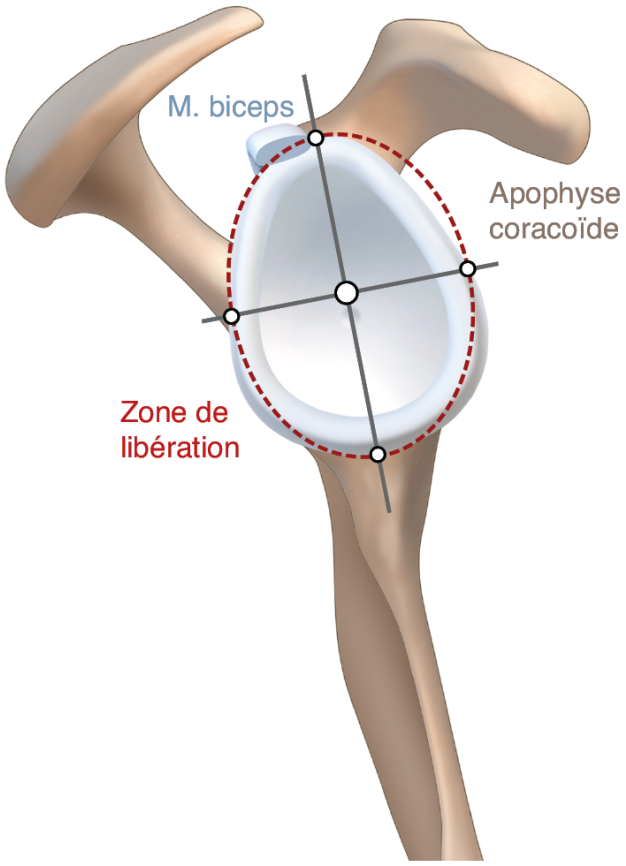

Figure 14: Peri-glenoid release

The glenoid construct should be fully seated in the cavity and the top screw should target the base of the coracoid process. (Fig. 15).

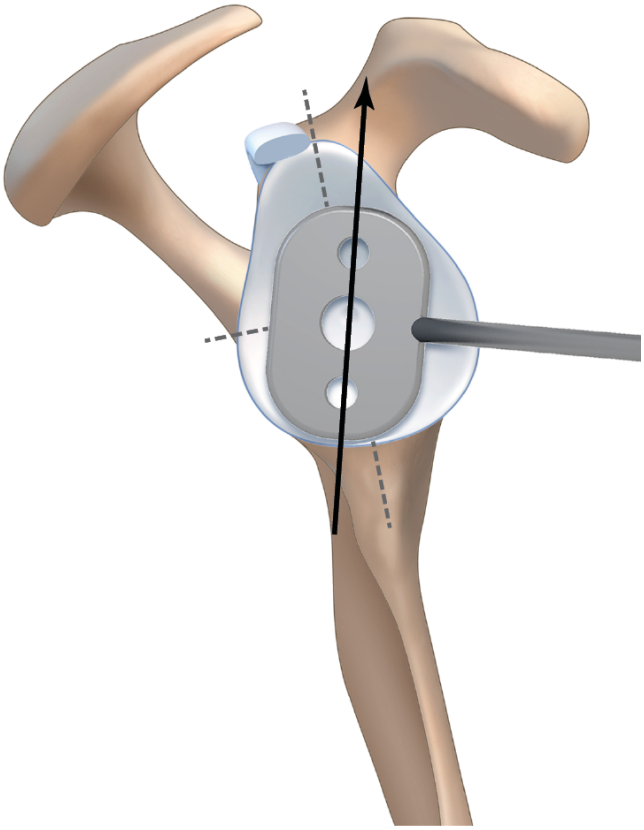

Figure 15: Positioning the glenoid construct

Any subscapularis repair should not affect passive external rotation.

The thickness of the metaphyseal insert depends on soft tissue stability and tension (deltoid, conjoint tendon) and on the size of the bone cut.

Post-operative care is standard and should not be any different to a stemmed implant. Immobilizing the joint for 21 days using a small abduction pillow offers greater comfort and external rotation (Fig. 16). It can be removed for daily activities, without pain and avoiding internal rotation. However, the surgeon should act according to his/her instincts and habits.

Figure 16: Abduction pillow

CONCLUSION

A stemless TSA is easy, fast and offers the possibility of easy revision, because it is easy to predict any subsequent cuts during the procedure. Stemless RTSAs follow the same rules as for traditional shoulder surgery, although it is important to pay more attention to the humeral metaphysis and preserve the bone stock, which is the very principle of a stemless TSA.

It is important to get into the habit of testing the bone quality of the metaphysis: no thumb test, no stemless implant!

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