MENTORS IN ORTHOPEDICS

PLACE OF THE STEMLESS SHOULDER IMPLANT IN 2023

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SUMMARY

Background: Traditional shoulder arthroplasty relies on intramedullary stems for humeral fixation. While effective, these designs present challenges regarding bone preservation, potential diaphyseal complications, and complexity during revision surgery. The development of stemless implants, initiated approximately 20 years ago with the TESS system, sought to address these issues by utilizing epiphysometaphyseal fixation.

Objective: This article reviews the 20-year evolution of stemless shoulder technology, evaluates current clinical indications for anatomical and reverse designs, and analyzes the advantages and limitations of these fourth-generation implants.

Key Points: Stemless implants utilize various fixation methods, including central posts, wings, or boxes, to achieve primary press-fit in the high-density bone of the proximal humerus. Clinical data indicate that anatomical stemless total shoulder arthroplasty (TSAa) provides functional outcomes and complication rates comparable to stemmed designs. Ideal indications include concentric osteoarthritis and post-instability arthropathy in patients with sufficient bone stock. For reverse total shoulder arthroplasty (TSAr), stemless options are more limited due to higher mechanical constraints, with inlay designs showing more consistent stability than early onlay models. Primary advantages include significant bone sparing, reduced intraoperative blood loss, shorter operative times, and simplified revision procedures. Conversely, poor bone quality, trauma, and severe osteoporosis remain primary contraindications.

Conclusion: Stemless implants have become a standard component of the shoulder arthroplasty armamentarium. They are highly reliable for anatomical procedures in patients with adequate bone stock. While stemless reverse designs are feasible, they require precise surgical technique and careful patient selection to ensure long-term stability.

KEYWORDS

Arthroplasty, Replacement, Shoulder; Shoulder Prosthesis; Osteoarthritis; Humeral Head; Prosthesis Design

Working with the TESS Group, we first envisioned stemless shoulder implants exactly 20 years ago, at the initiative of Biomet France.

The designers used version 1 of the TESS Implant, which had a modular and convertible design, for a total of 105 procedures throughout 2003, then assessed the results the following year (Fig. 1). In 2005, version 2 of the definitive TESS system was launched (Fig. 2). Thanks to satisfactory clinical outcomes at 5 years, [1] most companies gradually began including a stemless design in their implant range.

Figure 1: TESS v1 - Total Evolutive Shoulder System 2003. Screw fixation.

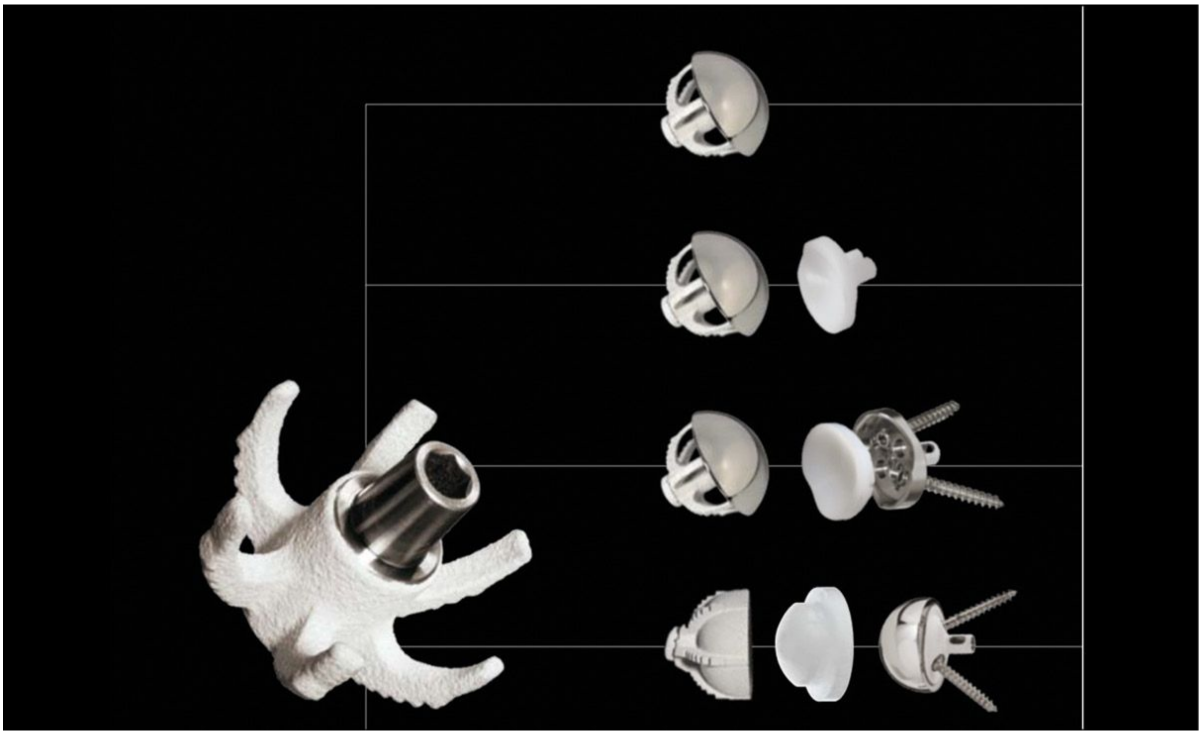


Figure 2: TESS v2 - Monoblock fixation - 2005. Anatomical and reverse design.

Having established the 'stemless' concept, we then went on to develop fourth generation shoulder implants which remain a French invention.

20 YEARS AGO, THE STEMLESS CONCEPT WAS BORN

The cup arthroplasty, first suggested by Steve Copeland in 1986, [2] was appealing due to the bone sparing and good outcomes for a humeral hemiarthroplasty. However, preserving the head made it extremely difficult to access the glenoid cavity and it was impossible to ensure correct implantation of the glenoid component for a total arthroplasty. The stemless concept is based on an implant impacted into the superior end of humerus after resecting the head. It comprises a large six-branched anchor designed for epiphysometaphyseal fixation. Developmental anatomic analysis of the humeral head reveals that the epiphysis is formed of three ossification centres (humeral head, greater tuberosity and lesser tuberosity) which fuse at age 7 to create a common epiphyseal mass; the funnel joining this mass to the diaphysis at the surgical neck forms the metaphysis (Fig. 3).

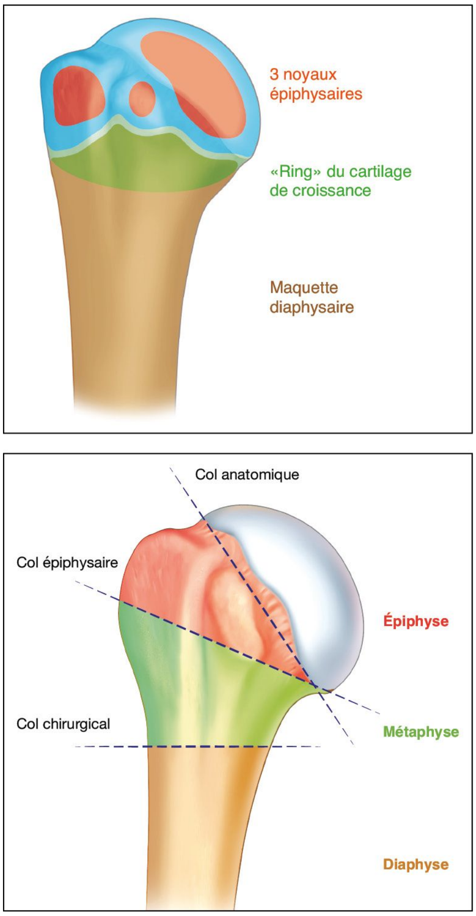


Figure 3: Developmental anatomy of the superior end of humerus: epiphysis, metaphysis, diaphysis.

This method of epiphysometaphyseal fixation then evolved into four main types, depending on the company:

- Central post with impacted wings or arcs
- Screwed central post
- Impacted box
- Box + central post.

Whether coated with sandblasted titanium, porous titanium or calcium hydroxyapatite, the fixation systems for these implants are designed to obtain a good primary press-fit, bearing in mind that bone density is optimum in the first centimetre beneath the head cut and densest in the outer ring (1cm) rather than in the middle. [3] (Fig 7).

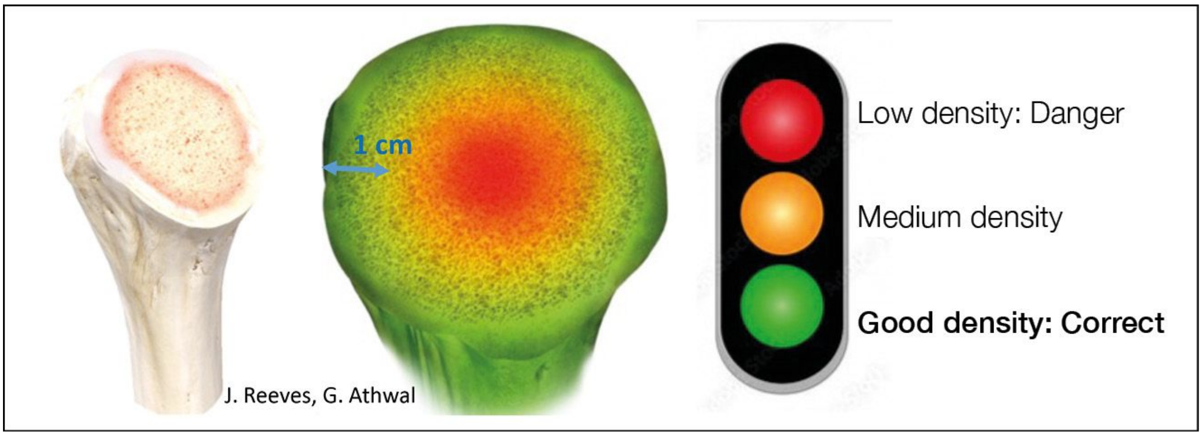


Figure 7: Bone density around the humeral cut.

The imprints left in the epiphysis by these various stemless designs show the bone sparing compared to designs with stems, even short ones (Fig. 8).

Figure 8: Imprints of stemless and short-stemmed implants.

STEMLESS IMPLANTS AVAILABLE IN 2023

After presenting the outcomes of the TESS implant, we witnessed a first wave of stemless designs comprising the Eclipse Arthrex in 2006, the Affinis Short Mathys in 2008, the Simpliciti Tornier in 2010, and the Sidus Zimmer in 2012. They were all available in an anatomical version only (Fig. 4).

Figure 4: First wave of stemless implants.

This was followed by a second wave of stemless implants that could be converted for use in both anatomical and reverse procedures: the Easytech from FX Solutions in 2012, the Nano Biomet in 2013, and the SMR S from Lima in 2014 (Fig. 5).

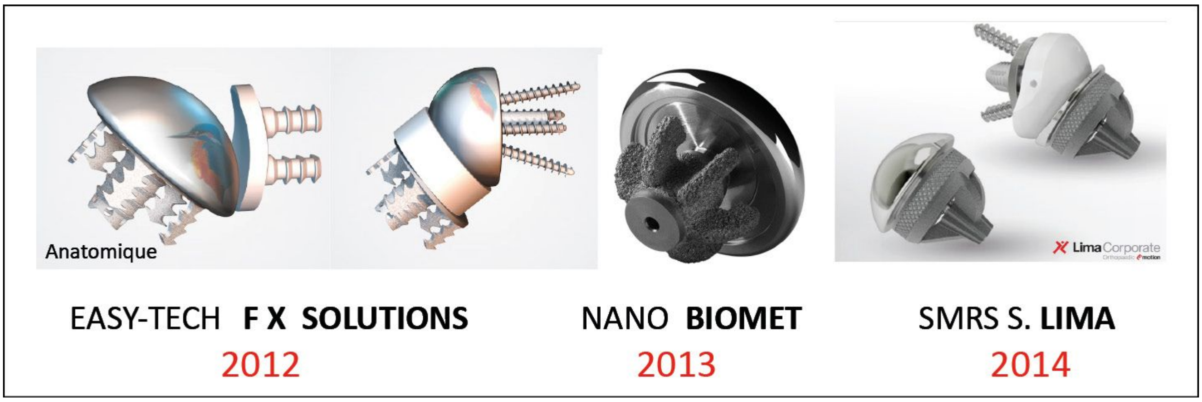


Figure 5: Second wave of stemless implants.

Finally, the third and most recent waves of stemless designs, exclusively anatomical, comprised the Global Icon DePuy in 2017, the Equinoxe Short from Exactech in 2018, the Isa Stemless from Move-Up in 2019, and the CS Edge from DJO in 2020 (Fig. 6).

Figure 6: Third wave: the most recent designs.

In 2008, Offer LEVY proposed a stemless reverse implant dubbed Versio which, in fact, was not truly stemless because it had a tiny stem that went into the medullary canal. Keen to jump on the stemless bandwagon it had, inadvertently, invented the short stem shoulder replacement (Fig. 9).

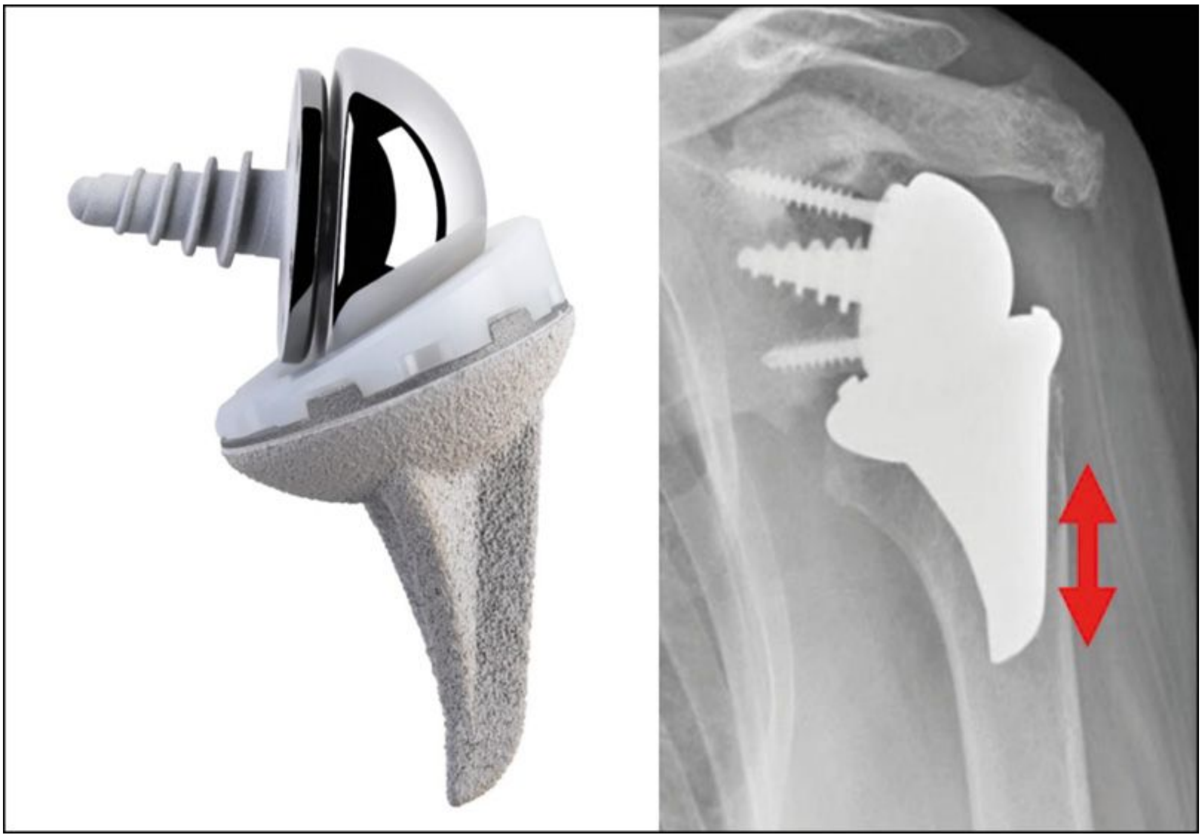


Figure 9: The Verso implant: Not stemless and but short stem.

Currently the global stemless implant market is represented by the following main companies:

- Zimmer-Biomet (Tess, Nano, Sidus) 32%
- Lima (SMR S) 27%
- Mathys (Affinis S) 26%
- Arthrex (Eclipse) 22%
- FX Solution (Easy-Tech) 20%
- Move-Up (Isa) 9%
- Tornier/Stryker 8%

Globally, sales figures are easily dominated by anatomical designs, with Lima selling 44% stemless TSAa (anatomical) vs. 9% stemless TSAr (reverse). Looking just at France, the birthplace of stemless, these figures from Lima are different yet again: 84% stemless TSAa vs. 43% stemless TSAr. Osteonecrosis of the humeral head is a good indication for a stemless implant because resurfacing the humeral head is a simple and minimally-invasive procedure. Likewise, a resurfacing hemiarthroplasty may be indicated for primary concentric osteoarthritis of the shoulder in patients under 50 if the glenoid is in good condition (Fig. 10).

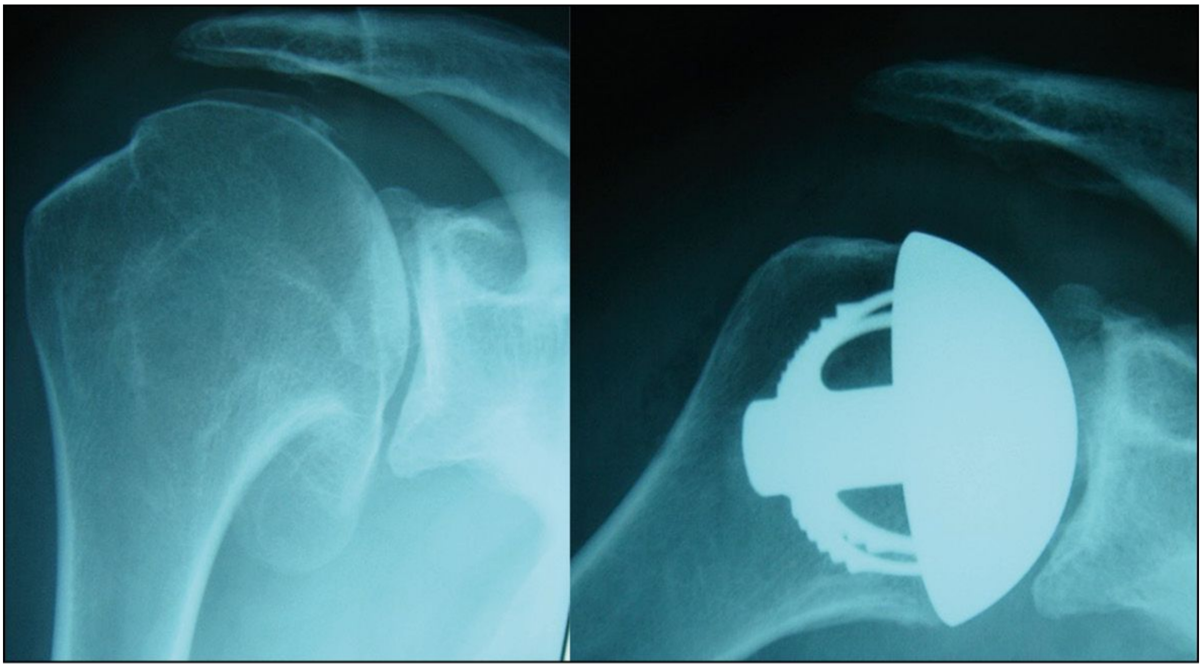


Figure 10: Hemiarthroplasty for osteonecrosis or osteoarthritis in a young subject.

Malunion of the proximal humerus, if recent enough to have not affected the glenoid cartilage, is again a good indication: a stemless humeral implant makes it possible to restore the humeral head without any of the constraints caused by offsets or tuberosity transfer (Fig. 11).[4]

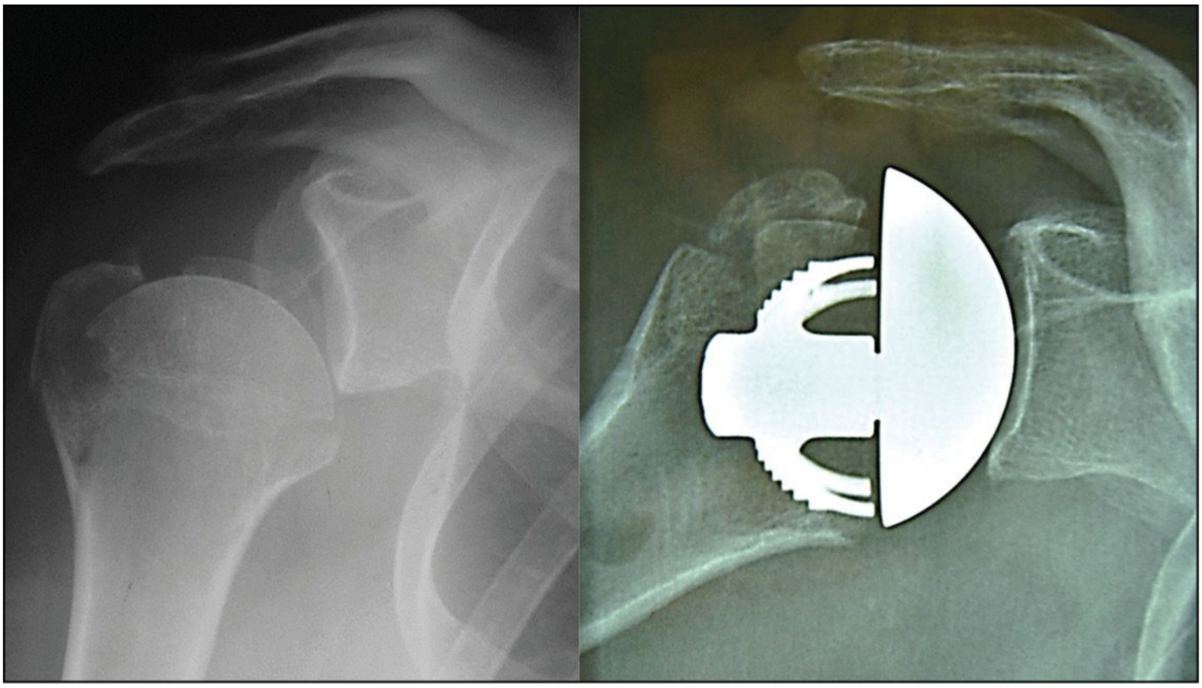


Figure 11: Hemiarthroplasty for epiphyseal malunion.

WHAT IS THE IDEAL INDICATION FOR A STEMLESS ANATOMICAL TOTAL REPLACEMENT?

Concentric osteoarthritis in a young subject is the perfect indication for stemless TSAa because there will be good-quality bone stock and a future revision will be made easier by the use of a stemless design. Longer survival can also be achieved by using a hybrid glenoid component to avoid the need for cement (Fig. 12).

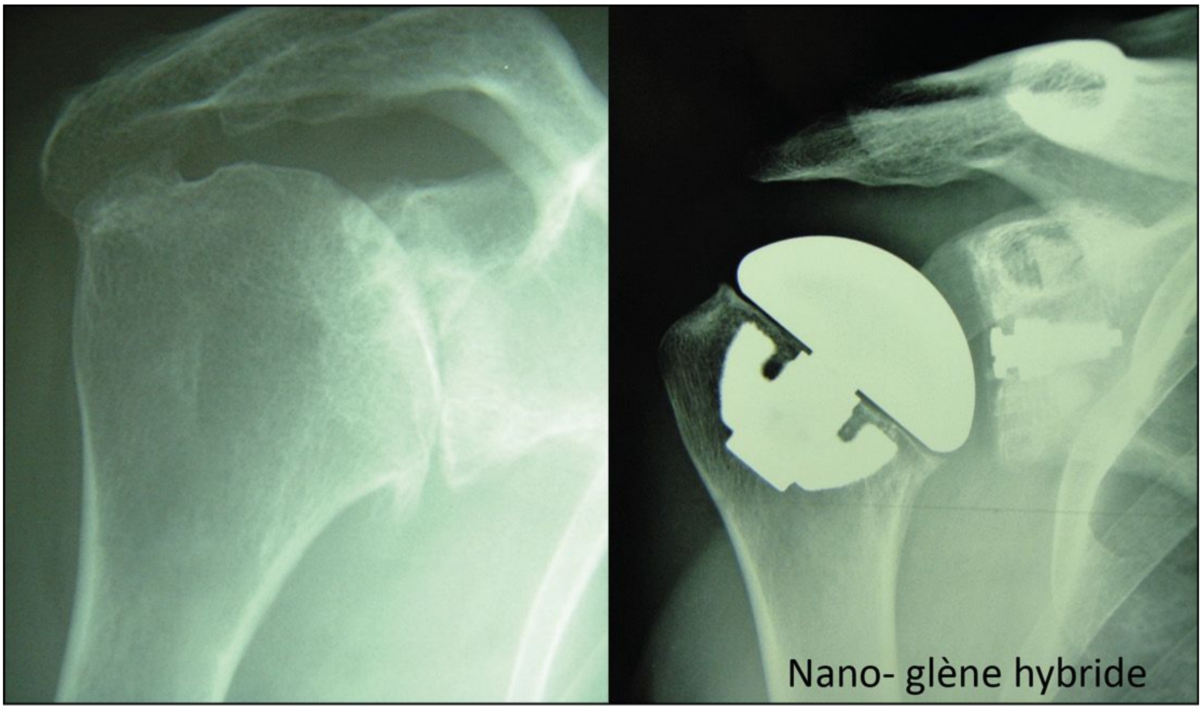


Figure 12: Stemless TSAa with a hybrid glenoid design for osteoarthritis.

Post-instability osteoarthritis, which usually occurs in relatively young subjects with good quality bone, is a good indication for a minimally-invasive anatomical TSA. A universal metaglene component should be recommended so that it can be converted to a reverse implant, should the instability recur or should there be loosening of subscapularis weakened by a previous bone block (Fig. 13).

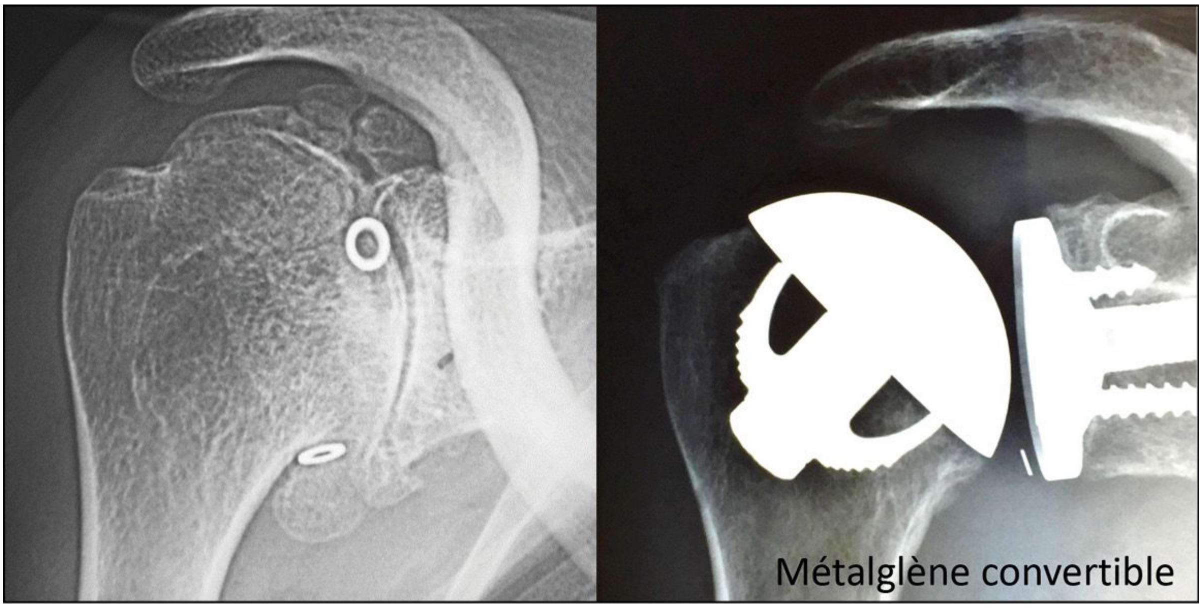


Figure 13: Stemless TSAa with convertible metaglene for post-instability osteoarthritis.

WHAT IS THE IDEAL INDICATION FOR A STEMLESS REVERSE TSA?

Osteoarthritis with rotator cuff tear in a young subject is a good indication for a reverse replacement because the absence of a stem makes the procedure less invasive (Fig. 14). Complex malunion can also be treated with a stemless reverse TSA, since the procedure removes the need for any diaphyseal or tuberosity transfer thus avoiding any corrective osteotomy which is rarely beneficial (Fig. 15).

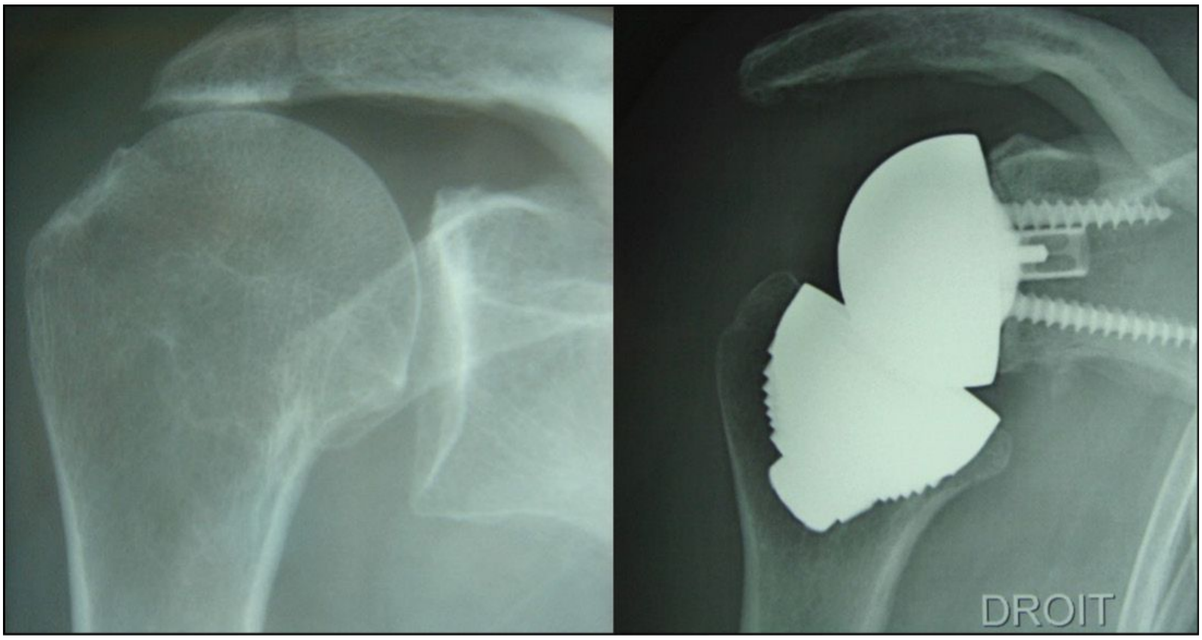


Figure 14: TSAr for osteoarthritis and a torn rotator cuff in a young patient.

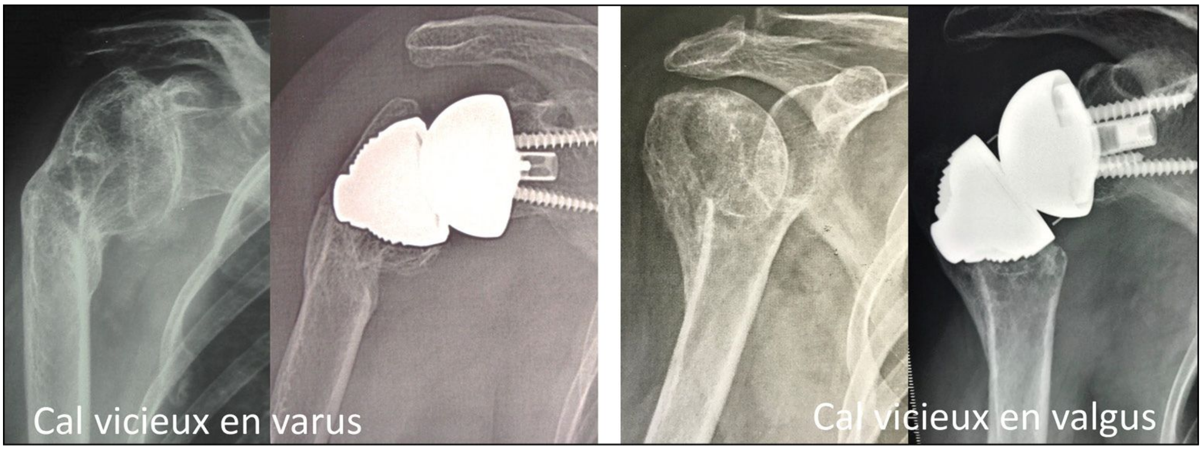


Figure 15: Stemless TSAr for complex malunion.

One of the benefits of stemless is the ability to freely modify the neck-shaft angle, which we initially recommended at 150° but now advise 135° or 140° to avoid notching, improve rotational range and achieve a better shoulder-humerus arch to ensure a good balance between humeral lateralisation and lowering (Fig. 16).

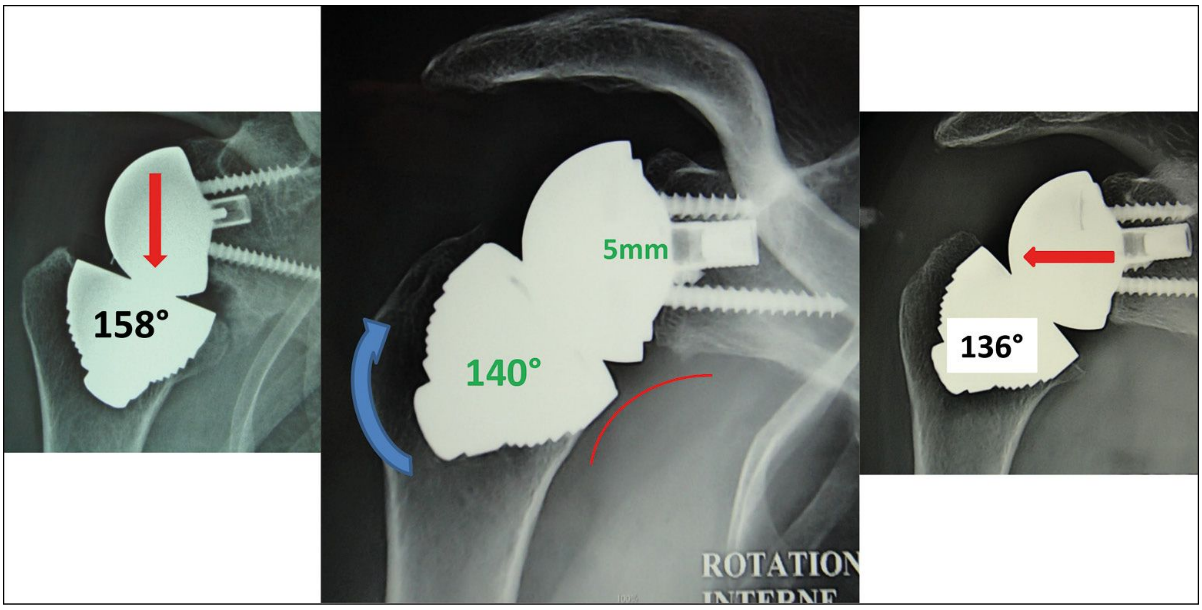


Figure 16: Benefits of stemless for free choice of neck-shaft angle.

WHAT ARE THE OTHER INDICATIONS?

Minimally-invasive conversion of TSAa to TSAr in case of cuff failure following stemless anatomical arthroplasty: if a conversion to reverse is required, it can sometimes be possible to keep the stemless implant, especially if either or both of the humeral and glenoid components are universal. If the humeral component is not convertible, its mandatory removal does not preclude the use of another stemless implant, provided the epiphyseal bone has not been overly weakened (Fig. 17).

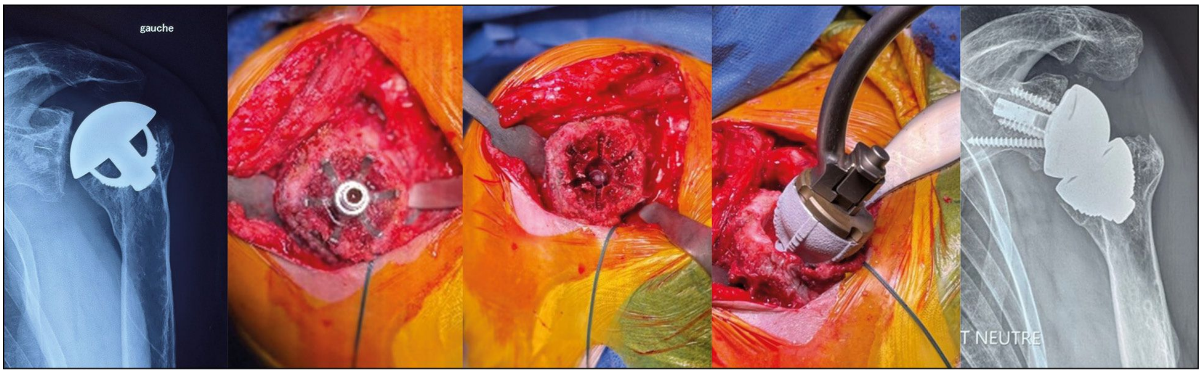


Figure 17: Conversion from stemless TSAa to TSAr.

De-escalation during revision of a poorly-positioned humeral stem in a young subject is another option offering elegant simplicity. The cement sheath can even be left in place provided there is no sepsis (Fig. 18).

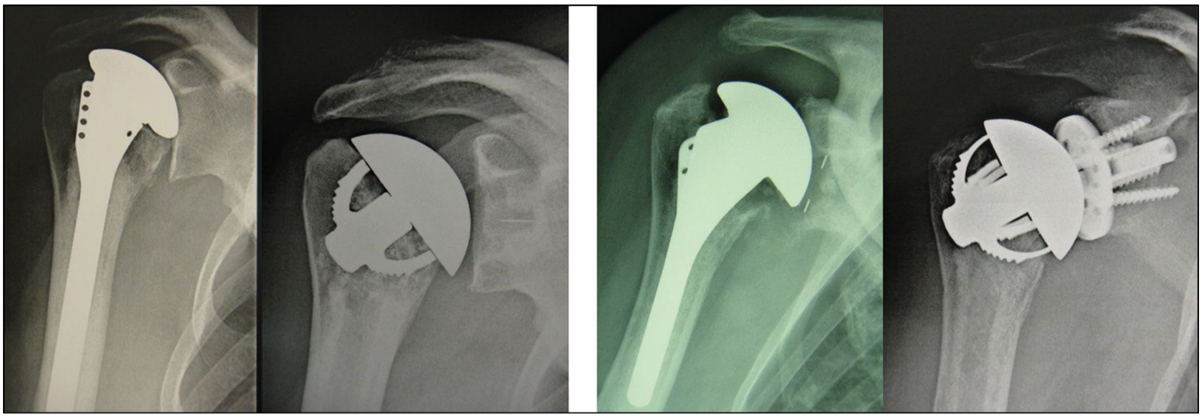


Figure 18: De-escalation for revision in a young subject.

WHAT ARE THE ADVANTAGES OF STEMLESS IMPLANTS?

There are four main advantages:

- Bone sparing.
- Simple procedure, without the constraints of offsets and any dysmorphia or epiphyseal malunion.
- No stem-related issues such as incorrect positioning, fractures, stress shielding (Fig. 19).
- Easier future revisions with no accessory procedures or humerotomy, with conditions comparable to those of a primary implant (Fig. 20).

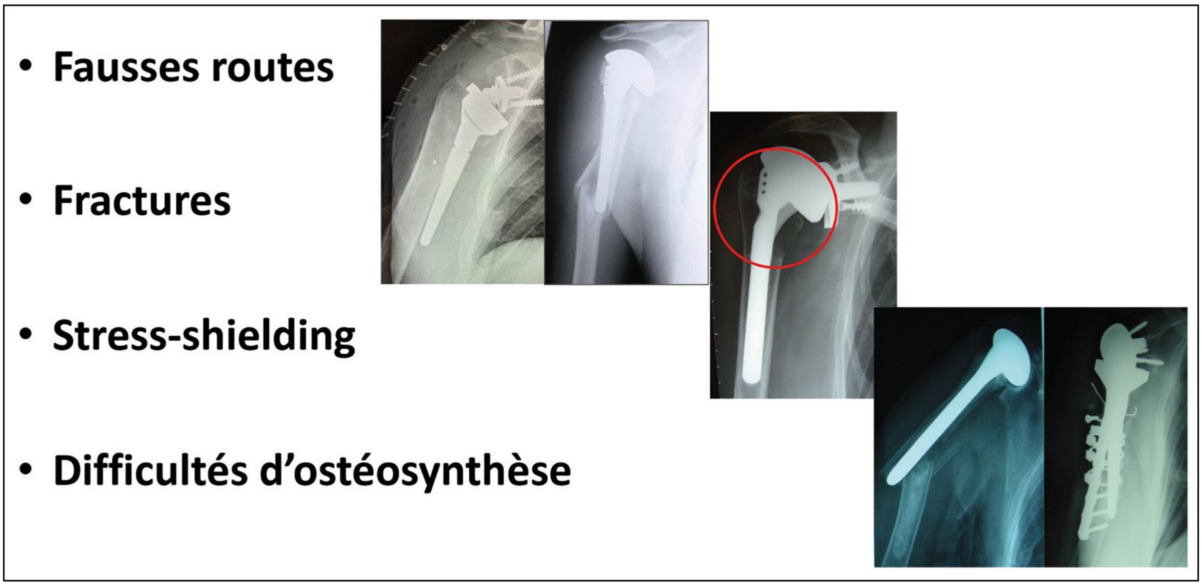


Figure 19: No stem-related issues.

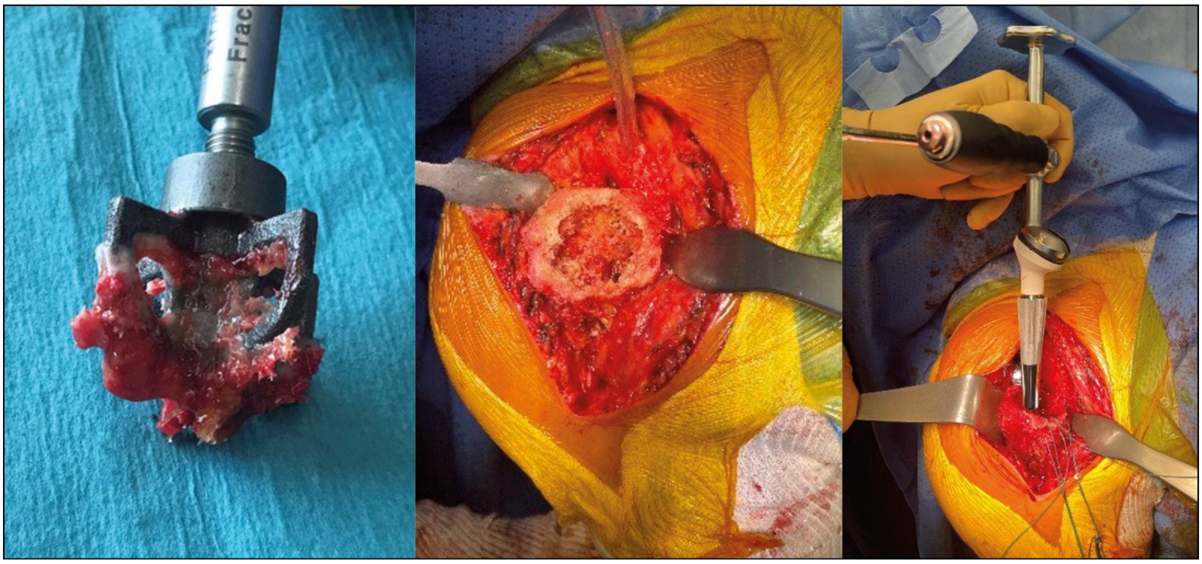


Figure 20: Revision comparable to a primary implant.

The secondary advantages include shorter operating time (11 minutes), less bleeding (1g) and a reduced risk of infection.[5]

In case of a subsequent fracture, standard osteosynthesis can be used, not hampered by the presence of a stem (Fig. 21).

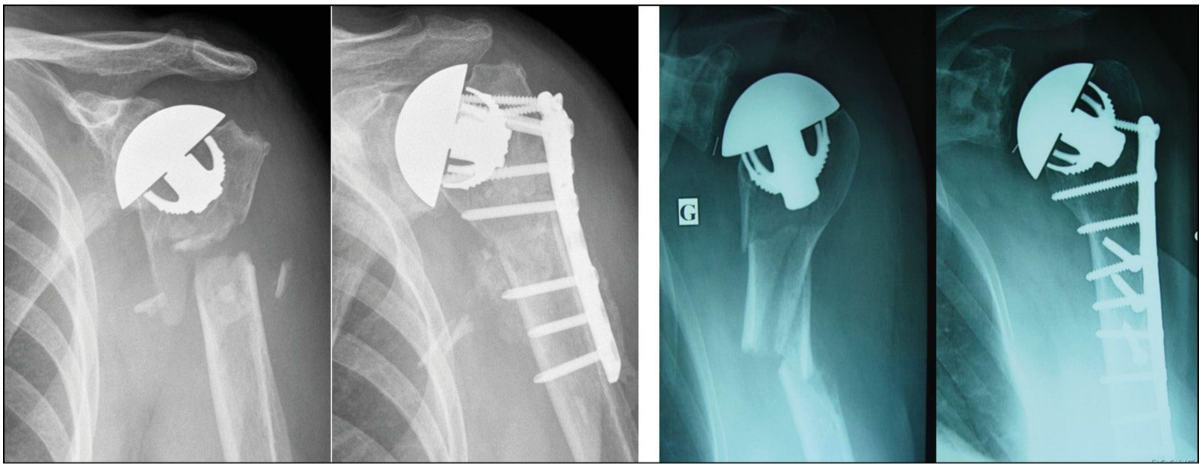
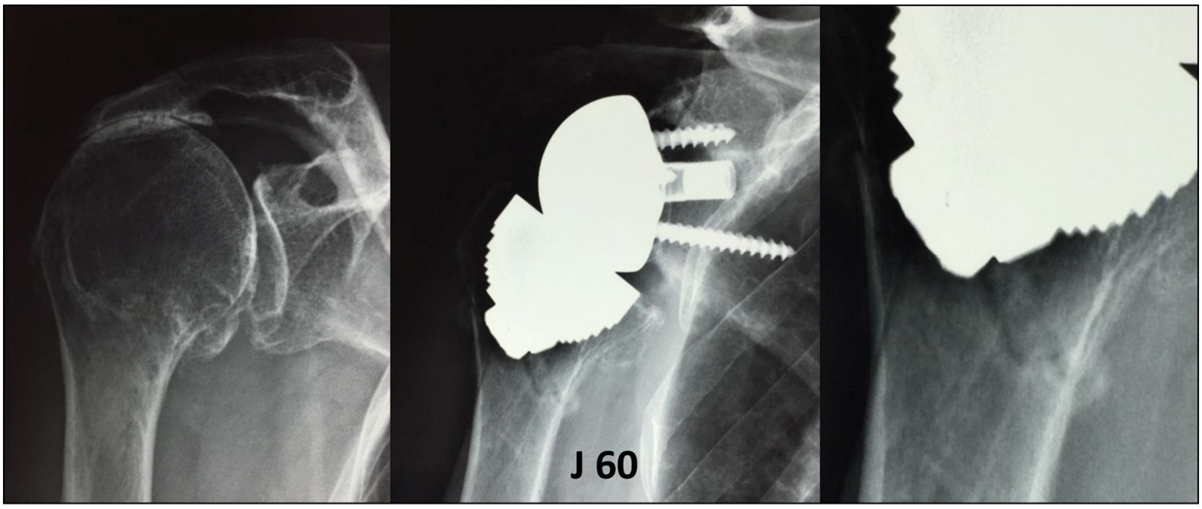


Figure 21: Standard plate osteosynthesis in case of humeral fracture.

Mediocre bone quality caused by long-term steroid therapy, osteoporosis and polyarthritis are contraindications to the use of a stemless design due to the risk of loosening or stress fractures (Fig. 22). Age is not in itself a limiting factor, provided there is sufficient quality bone stock.[6]



Insufficient epiphysometaphyseal bone stock is a limitation for stemless. The bone walls surrounding the humeral implant must be solid and encompassing. When preparing the glenoid cavity, the posterior spacer used to push back the humeral head can sometimes damage the anterior wall of the humeral epiphysis, creating the need for a stem.

Mechanical overload in heavy manual workers or large arms, especially in certain women, dictate caution with stemless implants (Fig. 23).

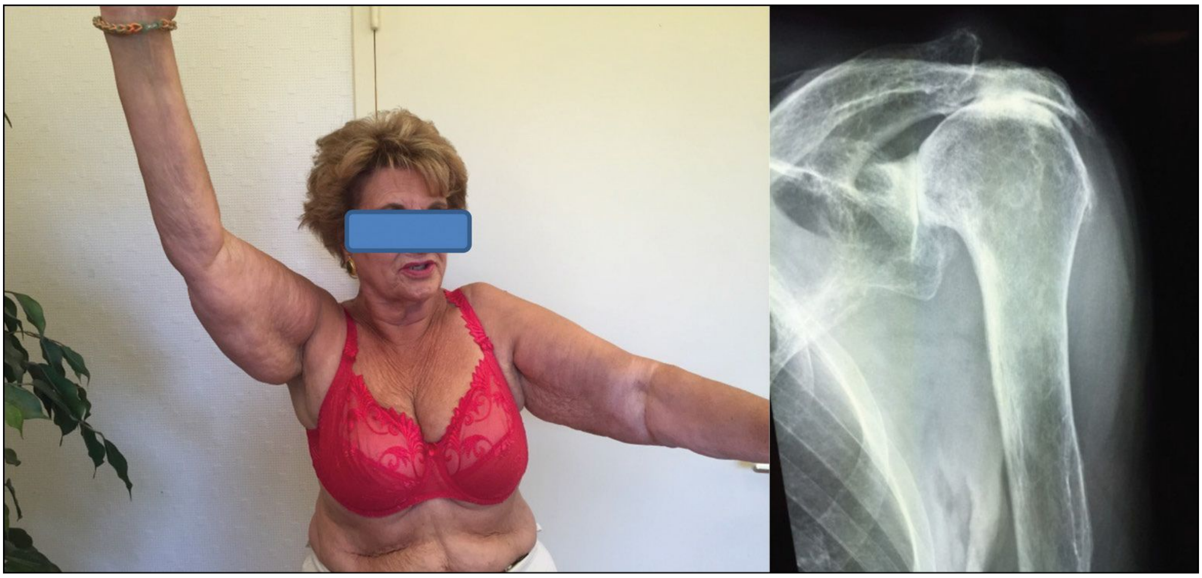


Figure 23: 'Large arms' is a risk factor for stemless.

Some young surgeons may find it tricky to fit a stemless implant and encounter two common risks: varus positioning or over-stuffing due to an insufficient cut motivated by a desire for bone sparing. The use of a guide stem can help with restoring an anatomical humeral head.[7]

Finally, stemless implants have no place in trauma settings where diaphyseal fixation with a stem is essential to restore a humeral head above the fracture.

DISCUSSION

With anatomical implants, the most long-standing models (TESS and Eclipse) have equivalent long-term outcomes to stemmed designs. [8],[9]

A recent meta-analysis of 962 patients reported comparable functional outcomes and complication rates for stemmed and stemless implants. [10]

Overall, whatever the fixation method used - flanged post, screwed post, box etc. - and whatever the coating type (HAP, sandblasted Ti, porous Ti), stemless anatomical implants are completely reliable.

As for reverse procedures which are limited by much greater mechanical constraints, few companies offer stemless reverse models.

Inlay designs such as the TESS and Lima SMR S give satisfactory mid and long-term outcomes. [11],[12] Onlay models give varying results: the Nano Revers from Zimmer-Biomet, introduced in 2013, was recalled in 2017 due to tilt and loosening [13] The Easytech reverse onlay from FX Solutions, launched in 2012, also initially had problems with tilt and poor osseointegration, which appear to have been resolved by changing the cut from 135° to 145° and a symmetric PE (Fig. 24).

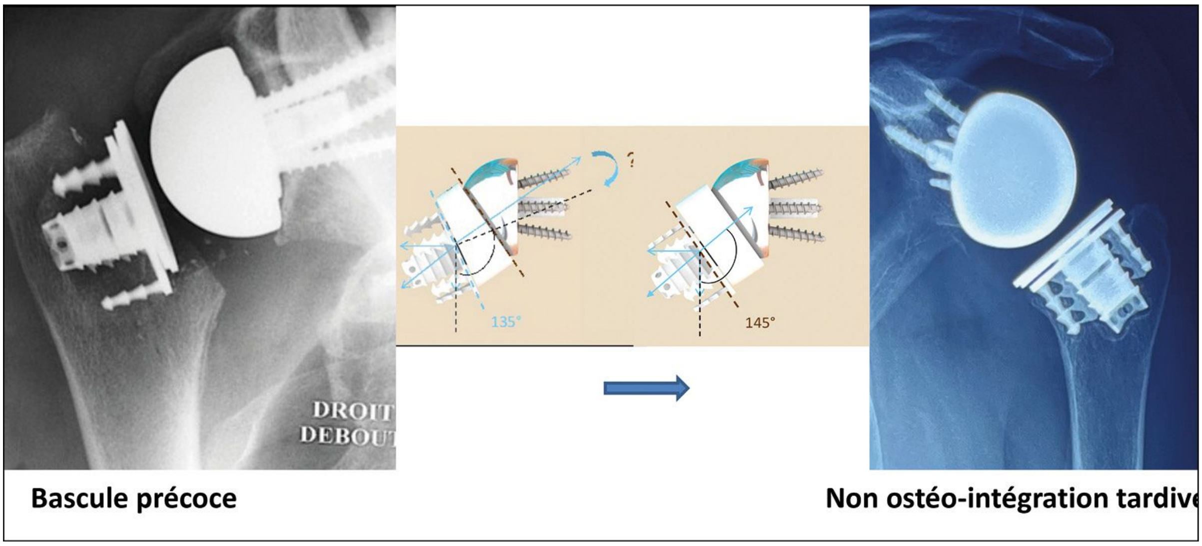


Figure 24: Additional constraints with onlay models.

There will soon be only two companies offering reverse stemless models because Zimmer-Biomet will shortly be halting production of its TESS for commercial reasons: The Lima SMR S, an inlay model made convertible thanks to a handy peripheral socket, and the Easytech from FX, an onlay design that can be converted using a central socket. There are strict criteria for the reliability of these two stemless reverse models, which require good bone stock and skilled implantation by an experienced surgeon.

CONCLUSION

Based on a recent meta-analysis by Joost Willems (2021) of stemless implants covering 1944 patients: [14]

Twenty years since it was first introduced, the so-called fourth-generation stemless shoulder implant has found its place in the treatment arsenal for shoulder arthroplasty.

Stems are usually unnecessary for anatomical procedures.

For a reverse replacement, stemless is only feasible if there is good bone stock and a skilled surgeon, preferably using an inlay model.

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