AAOS Now
Published 6/19/2023 | Jeffrey Berg, MD, FAAOS; Aaron Carter, MD, FAAOS; Thomas Fleeter, MD, MBA, FAAOS; Ryan Miyamoto, MD, FAAOS

Clinical | Shoulder & Elbow

Advancements in Anatomical Shoulder Replacement Surgery Improve Surgical Factors and Long-term Patient Outcomes

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Editor's note: *This article is the first installment in a three-part series on recent advancements in shoulder replacement surgery. Part two covers advancements in reverse shoulder arthroplasty.*

Shoulder replacement surgery has become increasingly commonplace and often is performed on an outpatient basis. This three-part series covers recent advancements in total shoulder replacement (TSR), including efforts to facilitate surgical techniques, reduce complications and costs, and improve patient experiences and outcomes.

The primary areas of advancement include implant design and materials, preoperative planning, pain control, and surgical instrumentation. A well-positioned TSR can be expected to last more than 20 years and is designed to alleviate pain and provide a functional shoulder.

Anatomic shoulder arthroplasty

Many of the recent shoulder replacement component materials are similar to those used in lower-extremity arthroplasty. Investigators have identified material alternatives for the humeral head to reduce wear and osteolysis to extend implant survivorship. Pyrolytic carbon (pyrocarbon) and ceramic heads have been used with good short-term outcomes.

Vitamin E polyethylene glenoid components have also been used with the expectation of reduced wear. As in lower-extremity implants, vitamin E polyethylene is noted to be an antioxidant that inhibits the oxidative degradation of ultra-high-molecular-weight polyethylene, therefore resulting in more stability and increased mechanical and fatigue strength of the implant. The expectation is that these benefits will translate into extended survivorship of the glenoid component and reduced risk of osteolysis.

Postoperative radiograph of an anatomic shoulder replacement.

Courtesy of Thomas Fleeter, MD, MBA, FAAOS

New technologies

In an effort to ensure that anatomic total shoulder arthroplasty results are more predictable and effective and that the procedure is easier to perform, there has been a surge in the development and utilization of 3D preoperative planning software to facilitate component placement. Typically, a preoperative CT scan is performed and combined with proprietary software.

Patient-specific guides or implants can be developed from the software. Use of this technology enables better visualization of anatomy, improved implant positioning, and proper reaming direction and depth.

Computer guidance can assist with the trialing of components and easier identification of potential areas of impingement. This technology can help address glenoid anatomy, notably in cases with altered anatomy or significant bone defects. Additionally, computer-guided preoperative planning appears to result in significantly improved glenoid position, though long-term outcomes have yet to be proven.

Virtual reality is gaining acceptance during surgery. Augmented reality (AR), in which digital information overlays actual objects, and mixed reality (MR), in which digital holograms and real-world images co-exist and interact, have increasingly garnered interest.

These new technologies enable surgeons to view preoperative plans or other needed data that are overlaid onto patients during surgery. AR and MR can provide intraoperative guidance for preparing the bone and positioning implants, and they offer the possibility of allowing remote surgeons and students to view surgery in real time.

Exposure

Subscapularis treatment during anatomic total shoulder arthroplasty has been controversial. Unlike in reverse TSR, in which the subscapularis can be expendable, the subscapularis must be intact for anatomic TSR to function correctly and survive. Consequently, surgeons have debated the best way to reflect the subscapularis and repair the tendon at the completion of the procedure.

Recently, techniques have been developed that spare the subscapularis, negating the need for release and repair. These techniques often call for specific instruments and windows proximal and distal to the subscapularis. Ross et al. have shown promising results, with only five percent of 77 cases requiring a subscapularis takedown or later conversion to reverse TSR.

Humeral implants

The primary advancements in humeral implants have focused on reducing the length of the stem and easing conversion to reverse shoulder arthroplasty. In the past several years, humeral stem length has been shortening from full-length stems to mini and micro stems. Stemless implants are also gaining acceptance.

The goals of a reduced stem length are to leave greater bone stock for potential revision, reduce the risk of periprosthetic fractures, and in the case of stemless implants, possibly minimize implant malposition. Use of shorter stems can reduce surgical time and blood loss and facilitate reproduction of the patient’s native humeral head position.

Reduction of stem length can result in easier anatomic humeral head positioning. Use of short stems and stemless implants has shown comparable outcomes to TSR with standard-length stems in terms of humeral loosening and the rate of future revision surgery. There also may be an added benefit of reduction in other humeral complications, such as fracture, decreased bone loss, and stress shielding.

Stemless implants have some limits in that there is no convertible platform. Poor proximal humerus bone quality can have a negative impact on the feasibility of using a stemless implant.

Convertible platforms enable conversion of an anatomic implant to a reverse implant without removing the stem. These types of implants make conversion from anatomic to reverse shoulder replacement simpler and safer with fewer potential complications. Because some conversions from an anatomic to a reverse TSR might require a more extensive humeral neck cut, a convertible platform cannot be used in all cases. Crosby et al. noted that only 80 percent of conversion platforms can be used in revision of anatomic shoulder replacements to reverse shoulder arthroplasty.

Glenoid implants

Glenoid retroversion is common during shoulder arthroplasty. Correcting glenoid retroversion can help prevent osteolysis and component failure; however, correcting this deformity may be technically challenging. The options consist of reaming the high side, bone grafting or using an augment to address the low side, or using a reverse shoulder implant.

Augments can have favorable short-term results. This option is best used in lower degrees of retroversion. No long-term data are available for use of glenoid augments to correct retroversion.

In lieu of deformity correction or traditional onlay glenoid components, an inlay component can be implanted.

Inlay components lie flush with the surrounding glenoid surface while correcting retroversion. Theoretically, this can achieve less edge loading of the implant, resulting in less glenoid component loosening. Additionally, inlay implants improve glenoid bone retention, as these implants require less reaming to correct excessive retroversion. These implants may be best for young and active patients. To date, short-term outcomes and complication rates are encouraging.

Just as there are humeral convertible platforms, some glenoid implants are also convertible. These have metal-backed anchoring systems that do not require cement. Short-term and midterm results have been favorable, with low implant-related revision rates and reduced complications upon conversion.

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