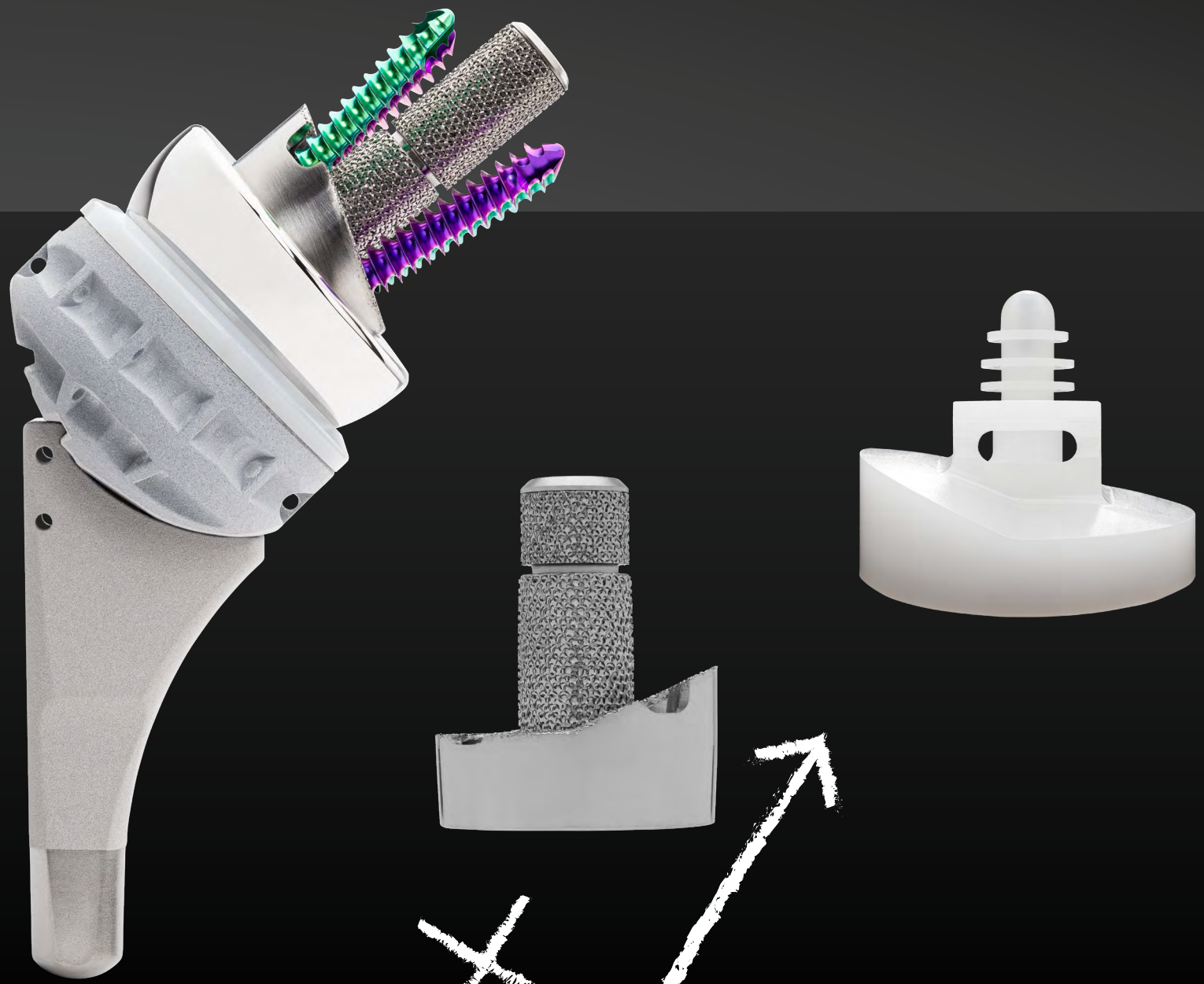
ECI PLAYBOOK

Glenoid Management

in Shoulder Arthroplasty



Arthrex®

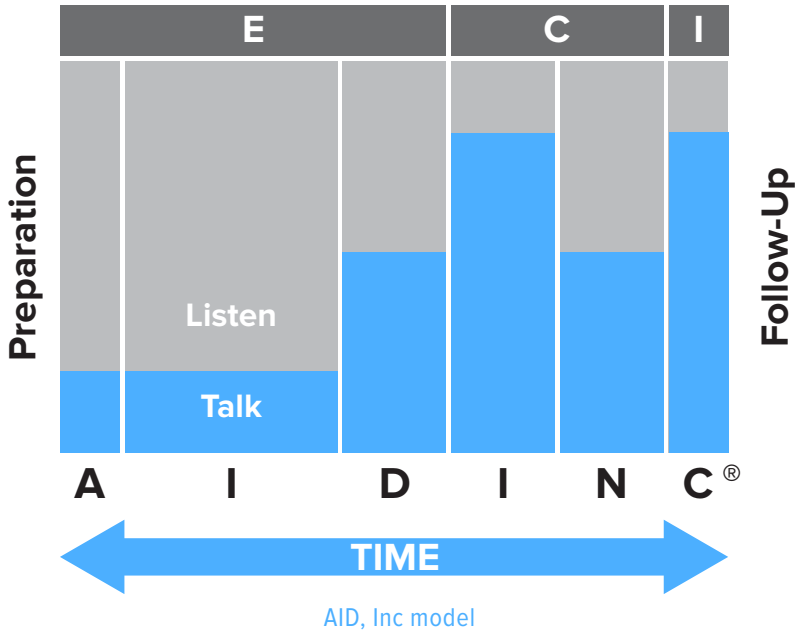
EDUCATE. CHALLENGE. INSPIRE.

Arthrex Customer Engagement Program

Introduction

ECI Playbook

Welcome to the Glenoid Management in Shoulder Arthroplasty Playbook with the Arthrex ECI Customer Engagement program.



AID, Inc model

The Arthrex ECI playbooks are organized using the AID,INC® process model (ie, approach, interview, demonstrate, validate, negotiate, close), which will help you prepare and properly plan for each customer interaction. This playbook briefly reviews the Arthrex ECI Program concepts in the beginning of each section.

Combining the sales engagement model with the educational resources will help you apply what you have learned, engage and interact with your customers, and give you the confidence to approach your customers.

Using the AID,INC process model, we **EDUCATE** ourselves about customers' goals and priorities during the **approach** and **interview** by adapting to their behavior style and asking thoughtful questions. Based on what we learn, we **EDUCATE** our customers by **demonstrating** viable solutions and differentiating our products.

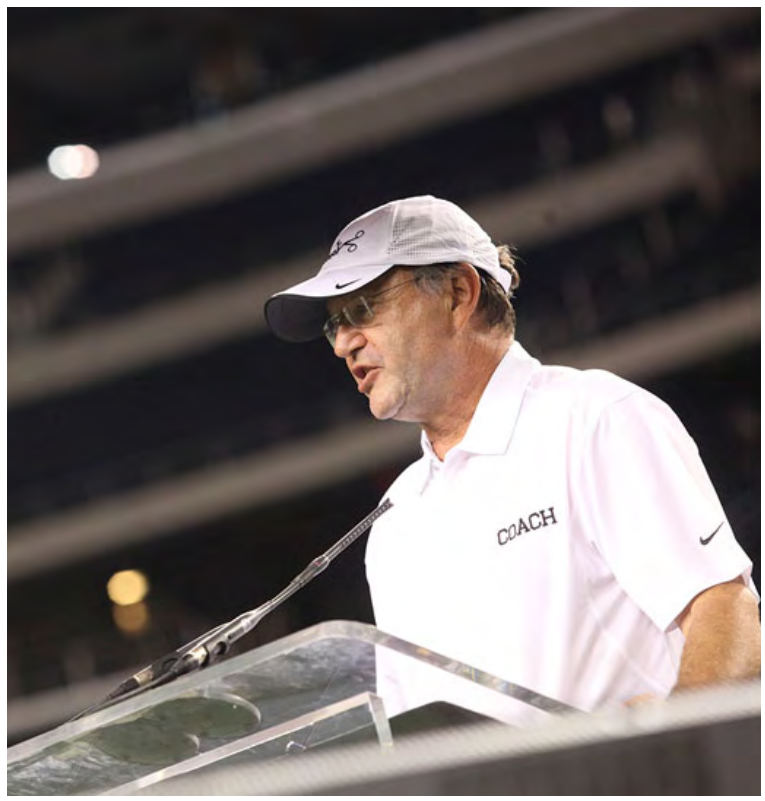
From there, we **validate** our claims with scientific evidence, **negotiate** through our customers' concerns or potential objections, and **CHALLENGE** them to deliver value through improved treatment and patient outcomes.

Through this collaborative process, we are able to identify customers' wants, needs, challenges, and goals and provide them with solutions. It also simplifies the **closing** process and **INSPIRES** our customers to choose Arthrex as a valued partner.

- **Pre-Call Game Plan**
- **ECI Reference Guide**

Coach's Corner

A Message from Arthrex President and Founder



In 2021, Arthrex supported more than 20,000 shoulder arthroplasty procedures in the United States alone. With the expansion of the anatomic and reverse total shoulder arthroplasty product line, you can support the simple to the most complex shoulder pathology that results from end-stage osteoarthritis, chronic irreparable rotator cuff failure, and proximal humerus fractures. Becoming an expert in identifying this pathology with your surgeons and providing the support of the Virtual Implant Positioning™ (VIP™) system offers patients the best value- and evidence-based solutions.

Since 1998, Arthrex has offered innovative solutions to complex, end-stage shoulder operations, beginning with the novel Univers™ fracture stem with in situ head height adjustability. In 2005, Eclipse™ stemless aTSA was launched in Europe and has endured the test of time and demonstrated long-term survivability with excellent clinical outcomes. Next, family of Univers aTSA implants (Univers II and Univers Apex systems) was developed with inclination and version variability that easily adjusted to patient anatomy. Finally, the Univers Revers™ system launched in 2013, giving surgeons the flexibility to intraoperatively adapt to presenting pathology with several implant configuration choices in one system to maximize patient outcomes.

Our reputation for innovation continues today with the vast array of solutions available to address any presenting glenoid pathology. Keep in mind, perspectives on how to treat complex glenoid pathology may differ between surgeons due to patient history/comorbidities, activity level, the risk for future revision, and surgeon experience.

This playbook is a how-to guide for initiating compelling conversations with surgeons about the glenoid options available to them, all helping to maximize outcomes and minimize complications for patients confronted with end-stage shoulder surgery. I am confident that between your expertise and our product line, Arthrex will be the only company to offer evidence- and value-based solutions for any shoulder surgery.

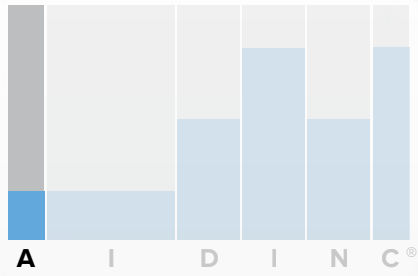
Reinhold Schmieding | President and Founder

Table of Contents

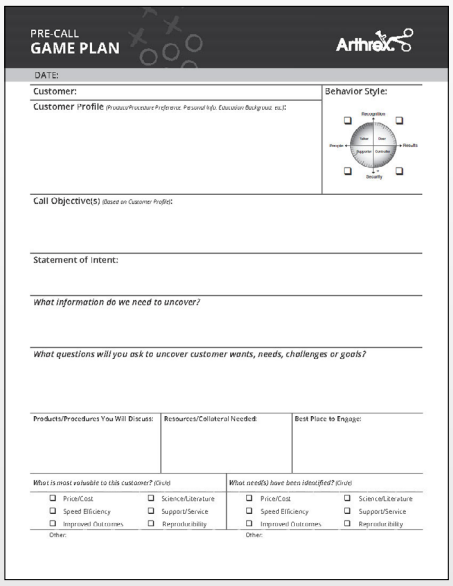
Approach

Action Guides™

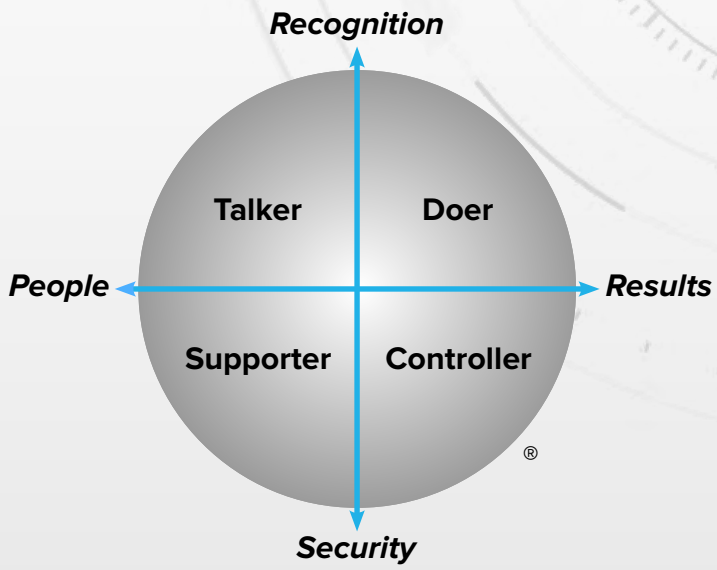
- **Tune** the world out and people in.
- **Put** people at ease and make them feel important.
- **Get** them talking about themselves.
- **Hold** eye contact and listen to how they feel.



Pre-Call Game Plan


PRE-CALL
GAME PLAN
Arthrex
DATE:
Customer:
Behavior Style:
Customer Profile
Call Objective(s)
Statement of intent:
What information do we need to uncover?
What questions will you ask to uncover customer wants, needs, challenges or goals?
Products/Procedures You Will Discuss:
Resources/Collateral Needed:
Best Place to Engage:
What is most valuable to this customer? (Circle)
What need(s) have been identified? (Circle)
Price/Cost
Speed/Efficiency
Improved Outcomes
Science/Literature
Support/Service
Reproducibility
Other:

Behavior Styles®



For further information, see the **ECI Reference Guide**.

Product Background and Rationale

Total shoulder arthroplasty (TSA) has grown into a $1.3B market with a procedural CAGR of 17.2%. With advancements in diagnostic imaging and preoperative planning, surgeons have a greater capability to recognize and appropriately treat abnormal glenoid pathology.

Arthrex's commitment to Helping Surgeons Treat Their Patients Better™ includes being at the forefront of treating the simplest to the most complex shoulder pathology, not just in sports medicine, but in arthroplasty as well.

Accordingly, both the Eclipse™ and Univers Revers™ total shoulder systems were T28 products in FY21 and will continue to be on the list for FY22. Eclipse procedures are forecast for 64% YOY growth between FY21 and FY22, while the Univers Revers portfolio is forecast for 34% YOY growth between FY21 and FY22. With the expansion of both product lines, Arthrex will continue to increase its market share, maintaining its stronghold in shoulder surgery.

Approach

Background and Rationale

Currently, Arthrex offers the following glenoid solutions for anatomic shoulder arthroplasty (aTSA):

- Congruent reamer (aka "ream and run")
- aTSA with all-polyethylene keeled, VaultLock®, and augmented VaultLock glenoids
- aTSA with the Universal Glenoid™ convertible baseplate and polyethylene insert

For reverse total shoulder arthroplasty (rTSA), Arthrex offers two families of glenoid solutions:

- Universal Glenoid convertible baseplate (aka convertible universal glenoid or CUG)
- Modular Glenoid System (MGS) (standard and augments)

Bone graft instrumentation is also available for surgeons who choose to augment the native glenoid with autograft or allograft bone. In combination with our industry-leading Virtual Implant Positioning™ (VIP™) system, Arthrex offers a product portfolio for addressing the glenoid in shoulder arthroplasty.

As you approach customers and develop conversations about shoulder replacement, it is important to understand the adoption and sales process.

Developing a sustainable business requires expert clinical knowledge, evidence-based algorithms, and the value proposition of your products, particularly compared to competitor products. Trust in a technology consultant's dependability, accountability, continuity, and competence are essential to a customer's decision-making process.

This playbook is designed to expand your existing foundation of shoulder arthroplasty knowledge and facilitate discussions with your customers about how Arthrex products are used to treat different glenoid pathologies. Understanding the content will enable you to have advanced discussions with surgeons and hospital administrators regarding the value of offering evidence- and outcomes-based solutions.

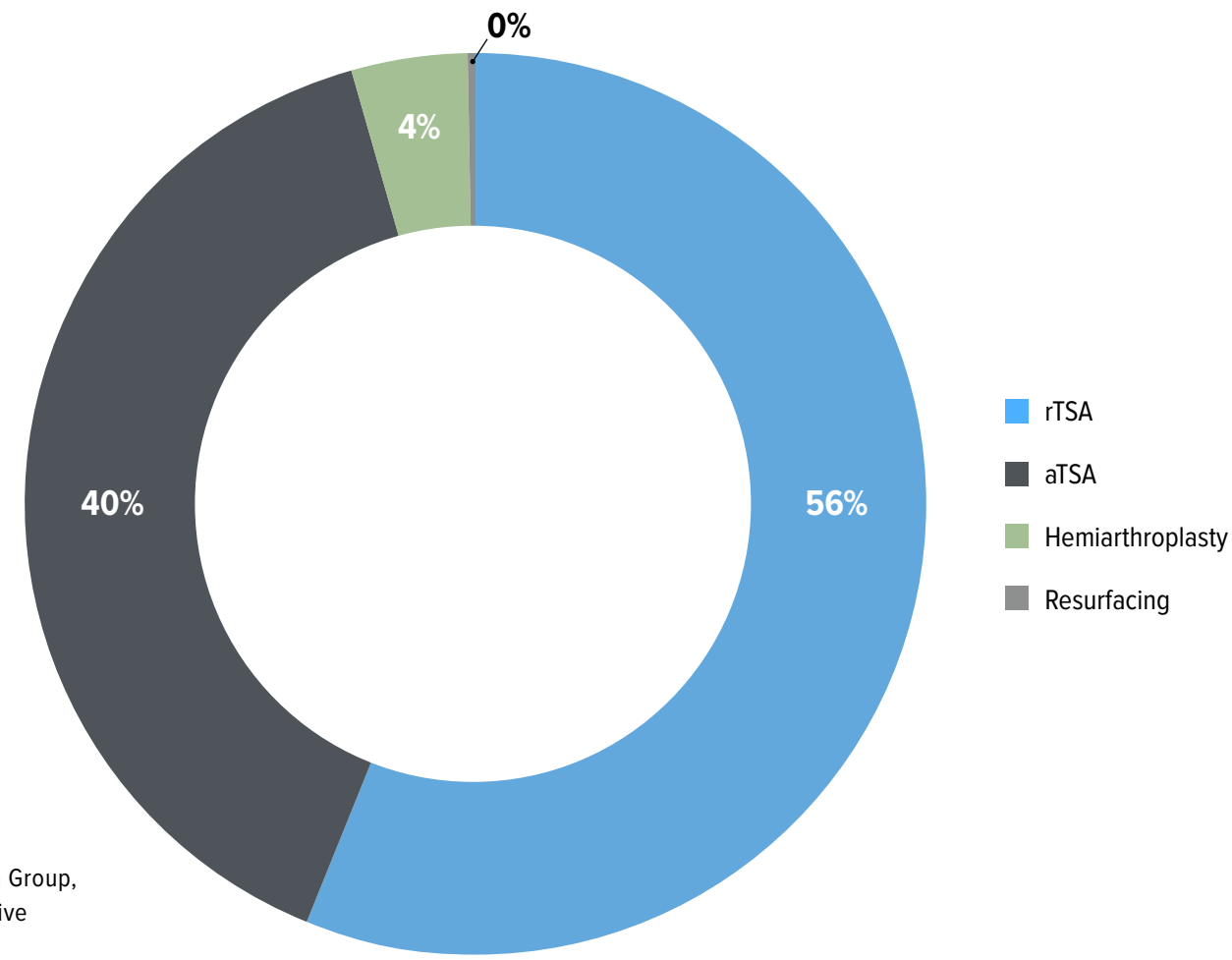
Approach

Market Overview

This year, approximately 240,000 shoulder replacement procedures will be performed in the United States. The majority of these will be rTSA (143,000) due to both soft-tissue and bone degeneration. Additionally, clinical outcomes for rTSA in proximal humerus fracture are significantly greater than aTSA or hemiarthroplasty.

Surgeons are encountering more severely abnormal pathology and need different implant configurations to maximize postoperative patient expectations and outcomes.

Arthroplasty Procedures in the US, 2021



Source: DRG Millennium Group, Small Joint Reconstructive Implants, 2021

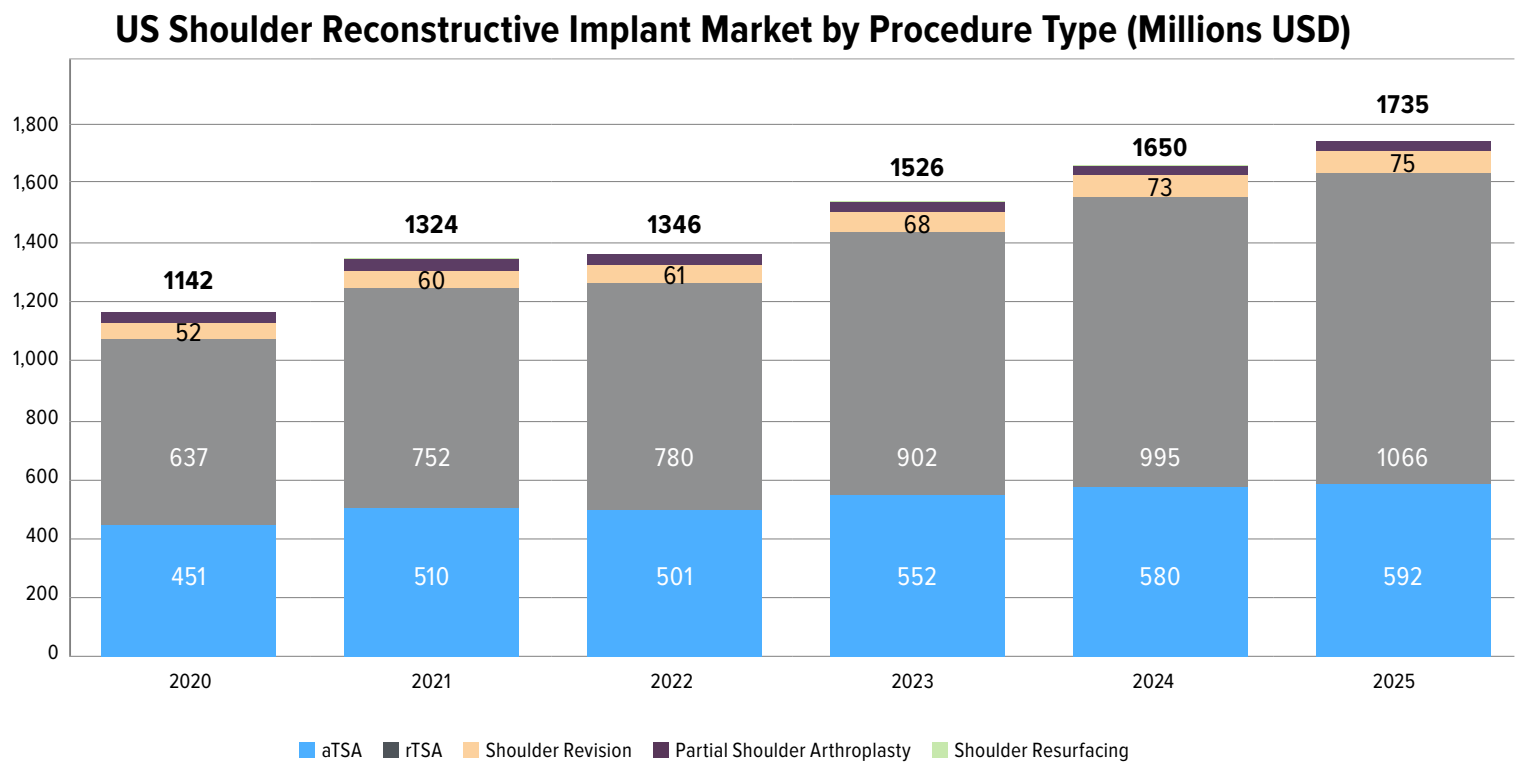
Historically, patients with osteoarthritis and an intact rotator cuff were treated with either hemiarthroplasty (if no glenoid degradation) or aTSA (if both the humerus and glenoid demonstrated degeneration). With assistance from 3-dimensional preoperative planning, hemiarthroplasty and aTSA are still the gold standards for patients with osteoarthritis and an intact rotator cuff. However, other factors, including patient age, comorbidities, physical demands, and glenoid erosion are all considered when treating these patients and, in some cases, rTSA may provide a more favorable outcome.

Approach

Market Overview

While a decline in hemiarthroplasty and aTSA continues, the popularity of rTSA is growing exponentially around the world. Most of these cases are for rotator cuff arthropathy. rTSA has become clinically accepted as a great treatment option for proximal humerus fractures.

Recognition of more severe pathology and increasing revision surgery stimulates innovation of implants that provide more predictable improvement in patient outcomes. Understanding the market, the pathology, and Arthrex implant solutions will provide surgeons with a greater ability to treat their patients better.



Source: DRG Millennium Group, Small Joint Reconstructive Implants, 2021

Approach

Primary Target Customers

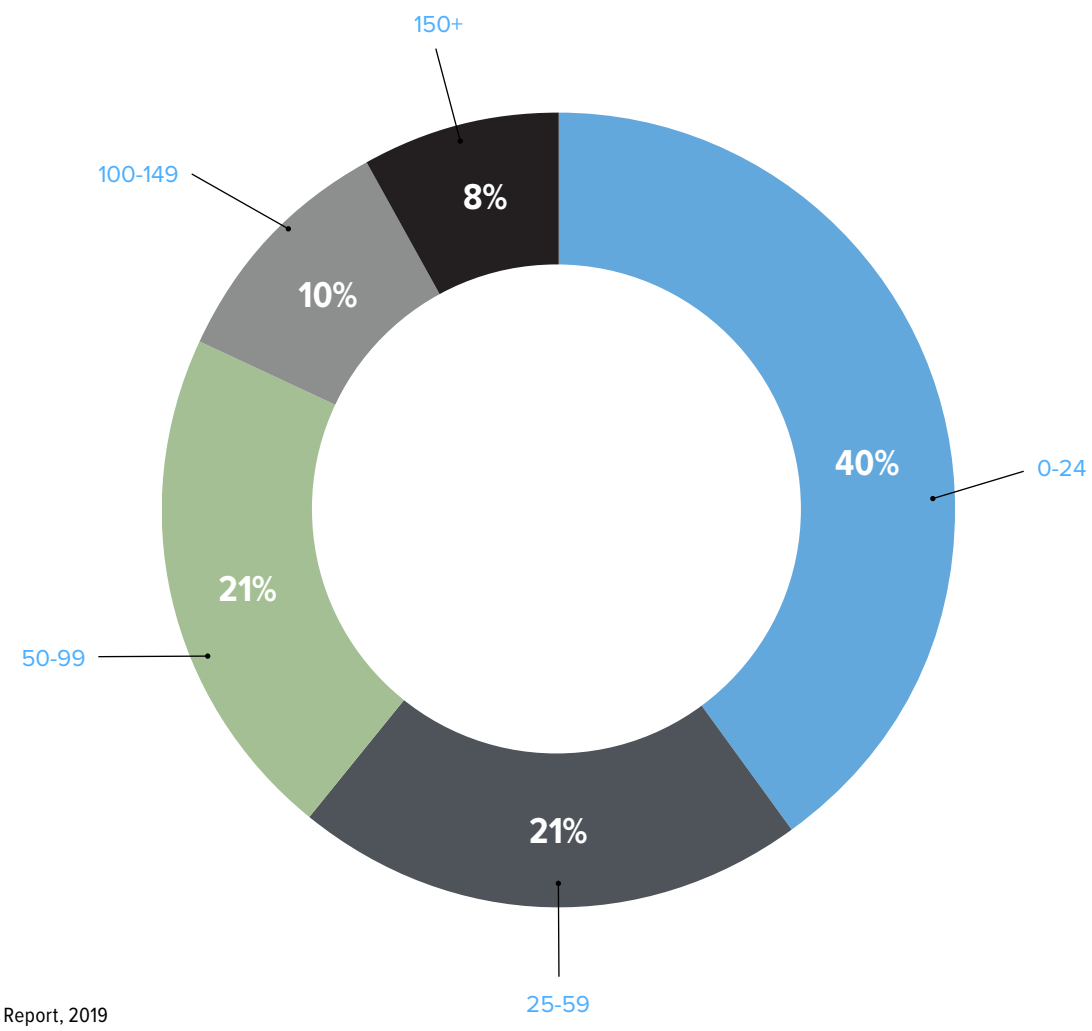
Representatives covering orthopedic surgeons who perform shoulder arthroplasty should be experts at understanding the complexity of atypical glenoid morphology and current best clinical practices. Understanding the role that Arthrex shoulder arthroplasty and other product lines play in the improvement of patient outcomes in these complex scenarios is paramount to developing trust and credibility with surgeons.

Surgeon targeting should be based on the answers to the following questions:

- What is the surgeon's experience in shoulder arthroplasty?
- Is the surgeon fellowship-trained in shoulder arthroplasty? Sports medicine? Trauma?
- How many annual cases does the surgeon perform, and of those cases, how many are aTSA and rTSA?
- Does the surgeon use preoperative planning software for shoulder arthroplasty cases?
- What shoulder arthroplasty system is the surgeon currently using and why?

To target customers effectively, it is important to categorize surgeons by volume and understand what categories represent the best opportunities and for whom. The market is divided into 5 volume-based categories: The best opportunities exist with surgeons performing 1-99 procedures annually. These three categories combined represent more than 80% of surgeons who perform shoulder arthroplasty. Keep in mind that each category should be approached differently.

Number of Procedures Performed Annually



Source: IQVIA, HPD Hospital and ASC Report, 2019

Approach

Primary Target Customers

The best opportunities exist with surgeons performing up to 99 procedures annually. The following three categories combined represent more than 80% of surgeons who perform shoulder arthroplasty. Keep in mind that each category should be approached differently.

1-24 Procedures Annually
These surgeons generally treat patients with less complex pathology. These surgeons' implant choices typically do not include complex revision implants or low-use specialty components. They base their decisions on good functional outcomes, minimizing complications, ease of use, and TC competence. Our product portfolio offers everything this group of surgeons is looking for (respected systems used by arthroplasty specialists, published clinical follow-up, etc). Additionally, you can introduce advanced technology like the Virtual Implant Positioning™ (VIP™) system, bone-grafting techniques, and metal augmentation, as well as stemless arthroplasty with the Eclipse™ system in the anatomic space. This group responds favorably to educational opportunities that expand their procedures, surgical skills, and patient volume. An Arthrex-loyal sports medicine customer using a competitive shoulder arthroplasty system is an excellent target for a TC to own and cultivate without management's aid.

25-49 Procedures Annually
This group of surgeons may have expanded interest in indications, techniques, and innovation in reverse shoulder replacement. They may be interested in reverse for complex glenoids, revision arthroplasty, and more specialized implants. This group is also a good target for TCs to own, but it may require management support. These surgeons can "move the needle" for your business and should be a focus target. It is still critical to own the sales process here because this is where trust is built and, ideally, the TC will own the relationship and technical support during cases. Arthroplasty managers should be used to augment the TC in a focused but supportive role within the sales process. These surgeons are likely to place a premium on superior biomechanics, advanced educational opportunities, advanced technology product offerings, patient-based expansion, and TC competence.

50-99 Procedures Annually
This group of surgeons should be owned by the arthroplasty managers in a collaborative endeavor with the leading or "point" TC. These surgeons are expanding their shoulder arthroplasty practice, expanding their procedures into the most advanced areas, might be fellowship-trained in shoulder arthroplasty, are likely viewed as the practice specialist or one of several, and have a deep understanding of the procedure and where it is headed. They have similar priorities to the 25-49 group but are more likely to treat patients with complex indications on a more frequent basis. There will likely be a high demand for advanced technology with a greater propensity to dig deeply into the nuances of products and components. Business Development Manager and Product Manager engagement will likely be required somewhere in the sales process.

These categories are excellent opportunities to target surgeons at different levels. They represent groups that will respond favorably to the Arthrex brand, the agency brand, and the relationships that have been built through our industry-leading sports medicine sales channel and product portfolio.

More than 60% of all shoulder arthroplasty procedures are performed within these categories. Rest assured, sustained efforts with these groups will result in building an expanding, sustainable shoulder arthroplasty book of business. The 25-99 group includes surgeons who are most likely to grow their arthroplasty practices year-over-year at a growth rate exceeding the industry CAGR, making them our "sweet spot." They will respond most favorably to our key value propositions; they place a premium on sound biomechanics, value our brand, and grow organically each year.

Approach

Primary Target Customers

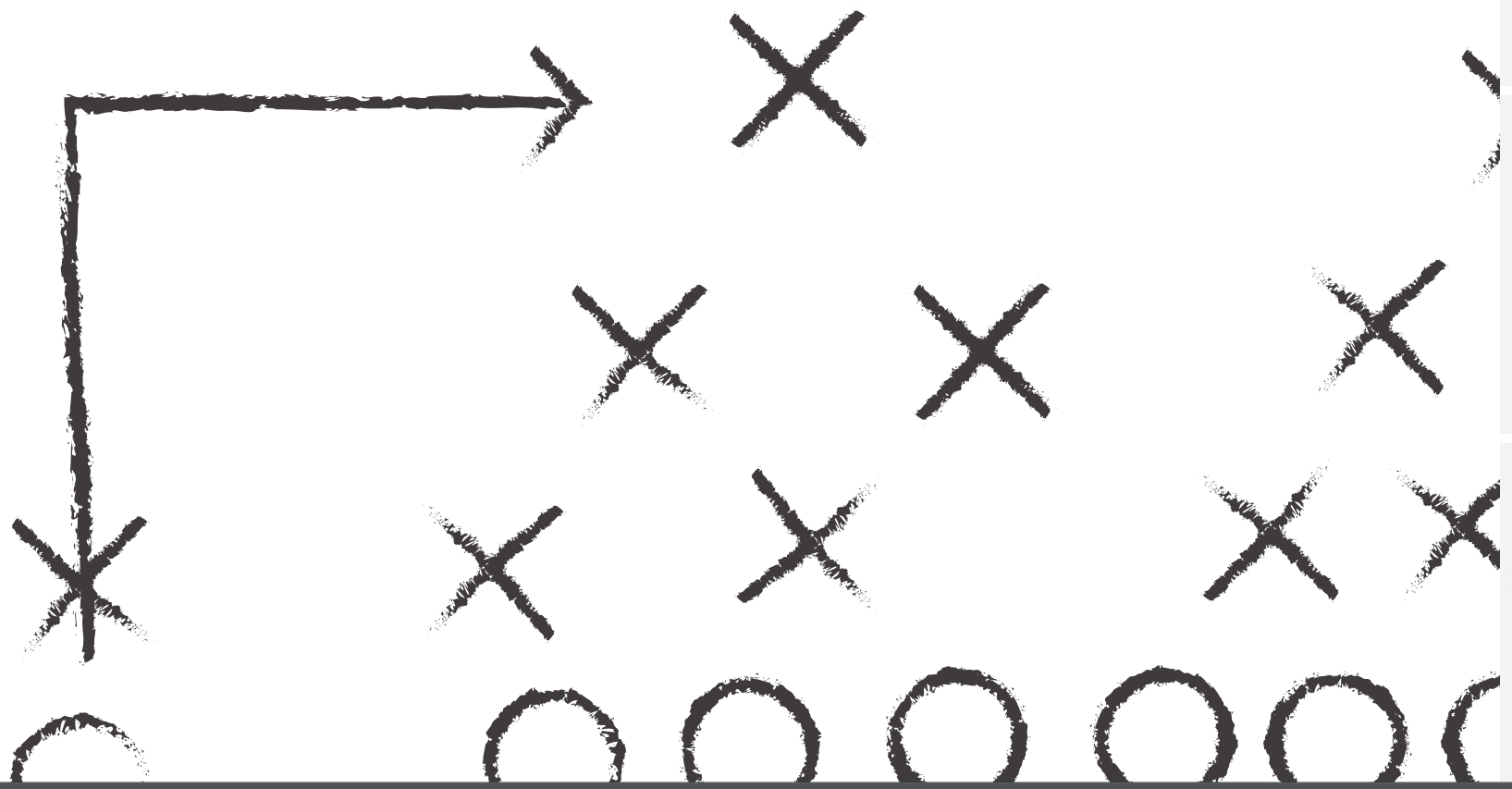
When selecting targets, it is also important to consider the type and brand of shoulder arthroplasty system a surgeon is currently using in practice. Our biomechanical value proposition can be most compelling to surgeons using:

- Simpliciti™ (Stryker), Sidus® (Zimmer Biomet), Equinoxe® (Exactech), Edge™ (DJO), and Catalyst CSR™ (Catalyst OrthoScience) stemless aTSA systems
- Aequalis Ascend Flex™ (Stryker), Comprehensive® (Zimmer Biomet), Equinoxe® (Exactech), and Global Unite® (DePuy Synthes) stemmed aTSA systems
- Aequalis Ascend Flex™ (Stryker), Comprehensive® and Trabecular Metal™ (Zimmer Biomet), Equinoxe® (Exactech), and SMR Reverse (Lima) systems

There are many others, but these products are the ones you are most likely to encounter. Representing about 80% of all shoulder arthroplasty implants in the US, it's important to consider that each of these designs can be improved upon when patient outcomes are the focus of the conversation.

Surgeons who perform more than 100 shoulder arthroplasty procedures annually can also be tangible targets. This category requires a rigorous “qualification” process to determine if they are a viable, worthwhile target. Your time is too valuable and should be spent developing surgeon targets that have a clear and tangible pathway to conversion. The qualification process should include input from agency and corporate leadership, your Arthroplasty Business Development Manager, and even the Arthroplasty Product Management team.

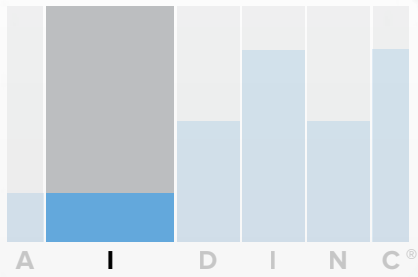
In your approach, it is essential to uncover and understand if the surgeon has an active design or consulting agreement with a competitive manufacturer, the scope of the agreement if there is one in place, surgeons’ goals and philosophies for their practice and patients, and their expectations regarding service, resources, and engagement. Expect the sales process to be lengthier and more rigorous in every aspect. These targets can be a very worthwhile and rewarding endeavor if they have been carefully “qualified” and pursued with teamwork and a good strategic plan.



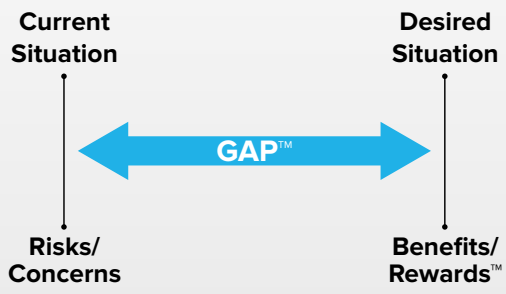
Interview

Action Guides™

- **Plan** and ask questions to uncover wants, needs, challenges, and goals.
- **Listen** to and paraphrase all points. If appropriate, take notes.
- **Identify** wants or needs and get agreement.
- **Communicate** your intent to create value by asking compelling questions.



The Gap Model™



For further information, see the **ECI Reference Guide**.

Craft Compelling Questions

The ECI interview process is **all about asking good questions**. Whether you are introducing new aTSA or rTSA products to an existing customer or converting them from another product, **you need to uncover their needs and challenges** to most effectively present how the Arthrex shoulder arthroplasty portfolio is the right solution. Following the ECI interview process, you will be able to identify strategies that best differentiate the Arthrex systems from competitive products and upgrade surgeons to the latest technology Arthrex offers.

Interview

Craft Compelling Questions

Current Situation

- What diagnostic tests do you perform to determine the presenting pathology?
- Do you use 3-dimensional preoperative planning for your shoulder arthroplasty cases?
- Do you use any technology to transfer your preoperative plan in the operating room?

Desired Situation

- What pathology do you consider so complex that it may determine which procedure you perform?
- What comorbidities (age, illness, etc) do you consider when determining operative procedures?
- Is there a place for:
  - “Ream and run” or other hemiarthroplasty
  - Bone grafting
  - Hybrid glenoid implants
  - Convertible glenoid implants
  - Augmented glenoid polyethylene/metal implants in your practice?

Risks/Concerns

- Which factors do you believe maximize function and mitigate complications in rTSA?
- What is your surgical decision-making process for ORIF or rTSA in treating proximal humerus fractures?

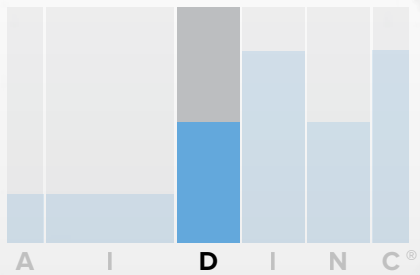
Benefits/Rewards

- Given altered glenoid pathology, do you correct or respect the native retroversion?
- How do you manage the subscapularis in both aTSA and rTSA procedures?
- How do you determine which patients receive a stemless or stemmed aTSA implant?

Demonstrate

Action Guides™

- **Repeat** the dominant wants, needs, or concerns.
- **Show** how Arthrex products fill wants/needs, solve problems, and create value.
- **Translate** Arthrex product features into customer/patient benefits.
- **Ask** for reactions, feelings, or opinions.

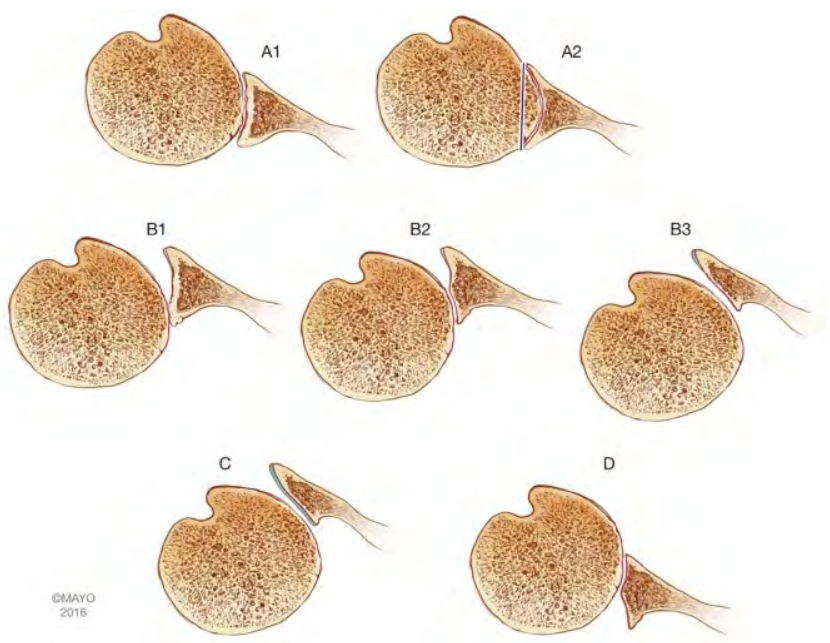


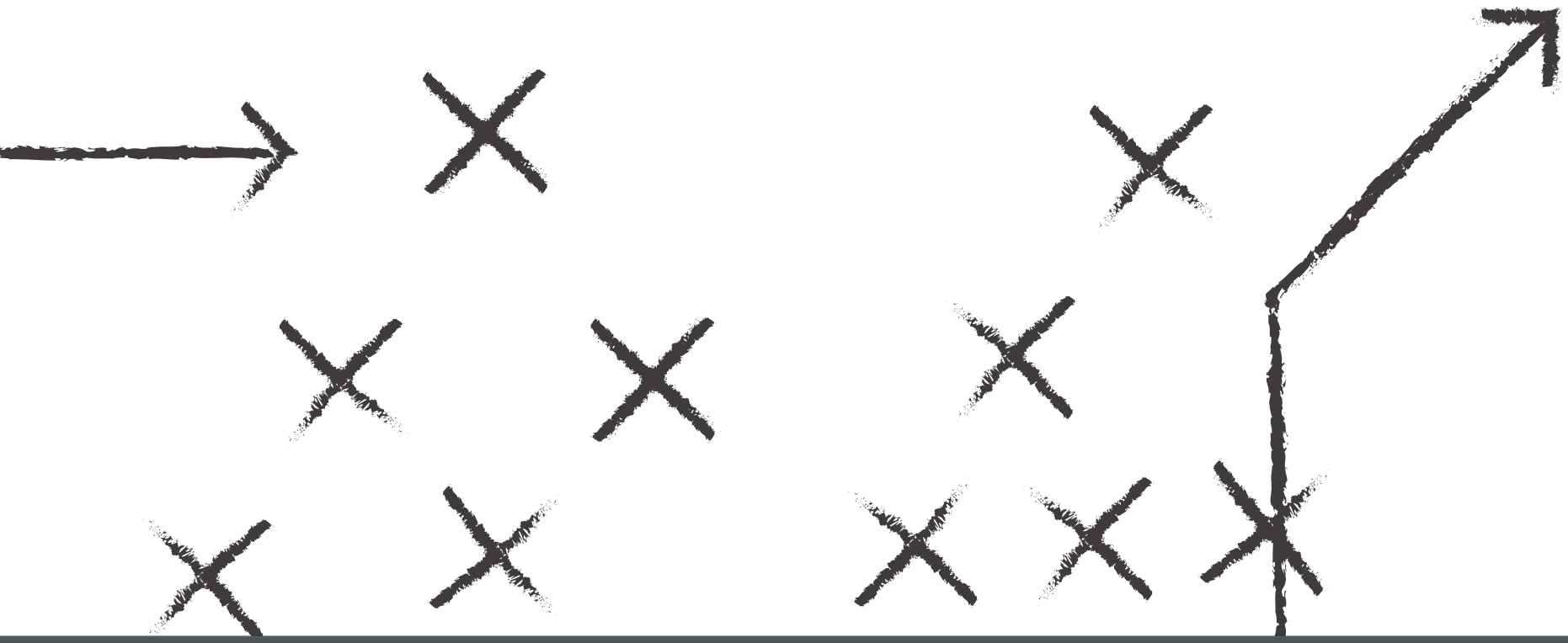
For further information, see the **ECI Reference Guide**.

Anatomy/Pathology

Understanding the anatomy and kinematics of the shoulder—particularly as it relates to shoulder arthritis, rotator cuff arthropathy, and proximal humerus fracture—is instrumental in guiding best clinical practices for managing complex pathology.

The glenohumeral joint is an articulation between the glenoid of the scapula and the humeral head. Arthritis (of primary or secondary causes) leads to loss of articular cartilage on either one or both sides of the glenohumeral joint. Further erosion on the joint can lead to bone loss on the humeral head, or more commonly on the glenoid. The Walch classification for glenoid morphology grades (A-D) the degree of bone loss on the glenoid.





Demonstrate

Anatomy/Pathology

In addition to bone erosion on the glenoid, the Humeral Head Subluxation Index (HHSI) describes the relationship of the humeral head on the glenoid and whether its position remains centered or it is subluxed in reference to the glenoid (**Fig. 1**).

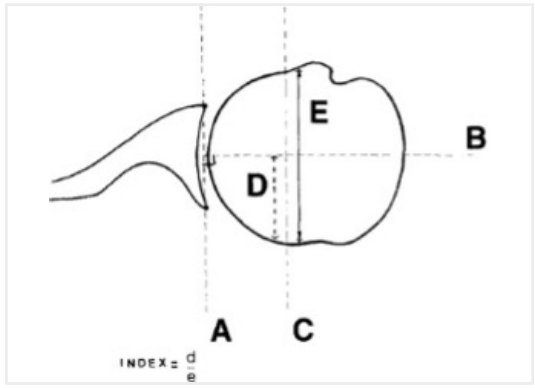


Fig. 1

The combination of Walch classification, HHSI, and other patient factors (rotator cuff integrity, bone density, daily function, and postoperative expectations) will drive surgeons' surgical decision-making based on their clinical experience, patient-reported outcomes (PROMs), and evidence-based medicine.

Additionally, the Favard classification has been used to classify glenoid pathology due to rotator cuff arthropathy, and describes the degree of glenoid inclination and humeral head superior migration (**Fig. 2**).

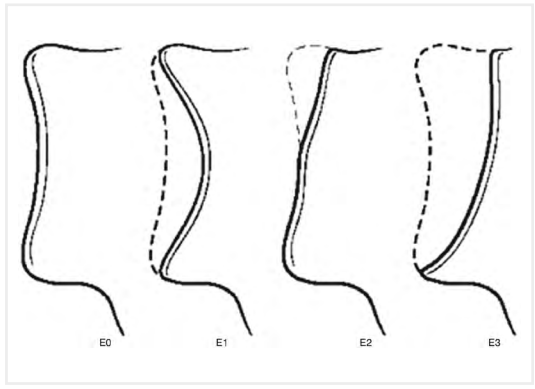


Fig. 2

It is important to recognize that retroversion (as described by Walch) and inclination (as described by Favard) do not commonly occur in isolation, but in combination with each other, particularly in the setting of chronic rotator cuff arthropathy. The use of 3-dimensional preoperative planning can determine the relationship between the two and offer optimal implant positioning based on implant fit, backside seating, and restoration of the center of rotation.

An important additional consideration of glenoid deformity is radius of curvature (ROC) Literature confirms there is a high degree of glenoid ROC variability in arthritic bone. The backside ROC of the glenoid implant, which is crucial to maximizing backside seating, must be considered relevant as the literature suggests overreaming of subchondral bone may lead to loosening and revision.

In the revision setting, removal of previously placed implants may leave a void within the glenoid vault.

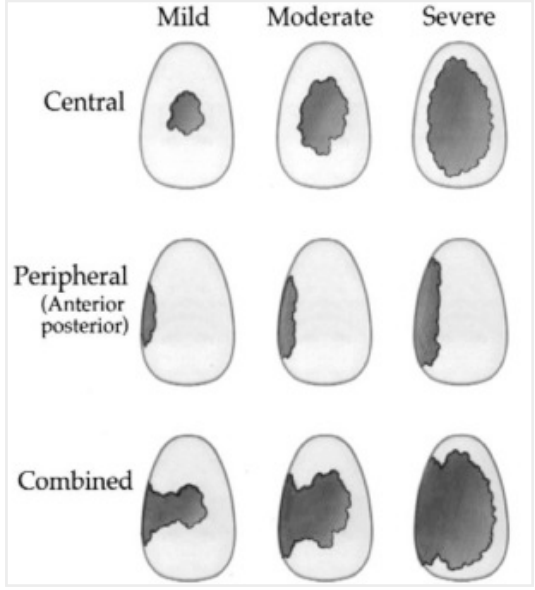


Fig. 3

These defects can be defined as central or peripheral (**Fig. 3**) and contained or uncontained (**Fig. 4**). Central, contained defects are more easily managed compared to peripheral, uncontained defects.

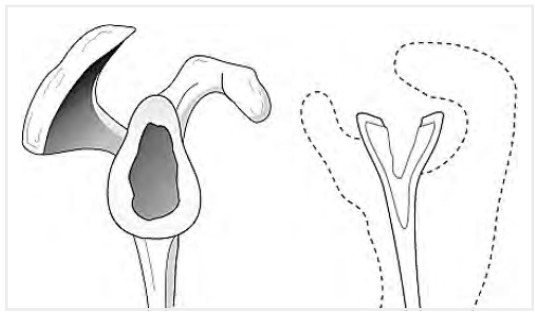
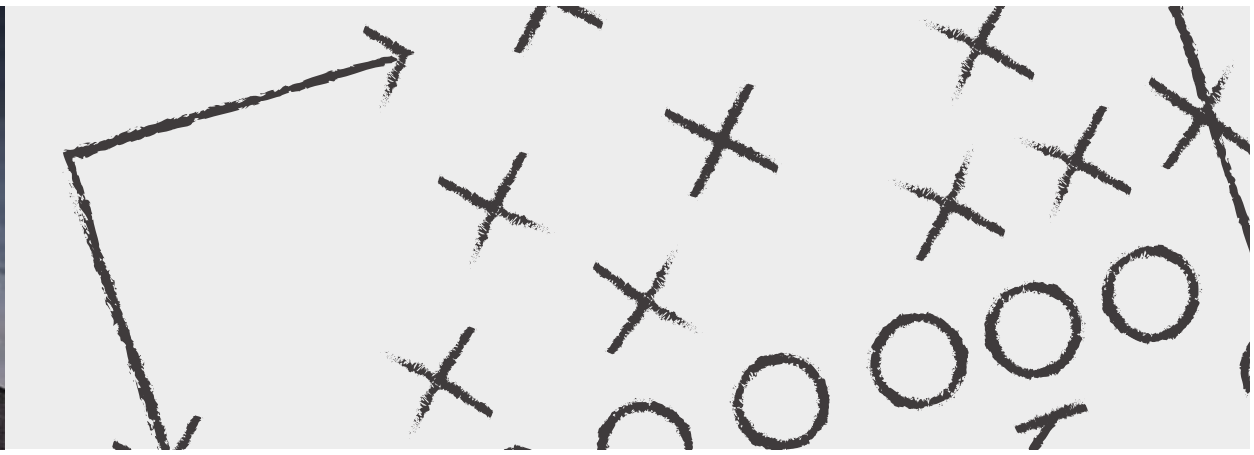


Fig. 4

Demonstrate

Surgeon's Perspective



Brian C. Werner, MD
Charlottesville, VA

Why the VIP™ System?

The VIP system has changed the way I perform shoulder replacements. I trained with very little use of preoperative 3D imaging or preoperative planning for shoulder arthroplasty, but in practice, found I often encountered unanticipated pathology. It quickly became evident to me that planning was key to performing the best possible surgery and optimizing patient outcomes. First, VIP planning allows me to better characterize the patient's 3D glenoid pathoanatomy so I am better prepared to address it intraoperatively.

3D assessment of glenoid morphology has been demonstrated in several investigations to be significantly different and potentially superior to 2D imaging.[1-4] Second, VIP provides me the opportunity to virtually place the glenoid implant prior to surgery, which is helpful even without the use of a transfer guide.

Finally, the VIP targeter is a simple, reproducible method for transferring my planned pin position intraoperatively. With the advent of patient-specific instrumentation and transfer guides, the use of 3D imaging has experienced even broader use, and has been demonstrated to significantly affect surgical decision-making and implant position.[5,6] At least one study has demonstrated that preoperative planning and 3D imaging resulted in a change in implant from TSA to RSA, something that happens not infrequently in my practice as well.[7] Finally, a recent study of ours was the first to demonstrate that obtaining 3D imaging resulted in lower revision rates after anatomic TSA.[8]

VIP planning offers several strengths. The planning can be done through a website without any downloaded software. This is a key advantage over several competitors, and is helpful for surgeons who are not frequently in front of the same computer.

The software is also intuitive and easy to use, requiring little training and guidance. Additionally, the engineers place the implants using FDA-cleared protocols, giving surgeons a starting point. The transfer instrumentation adds minimal cost and time to the case—a scrub tech can easily set it up during the surgical approach.

There is no need to order any instrumentation or additional drapes, and there is no annoying registration that needs to be completed before the case.

Demonstrate

Surgeon's Perspective

Integrating the VIP™ System Into the Practice: How Did I Do It?

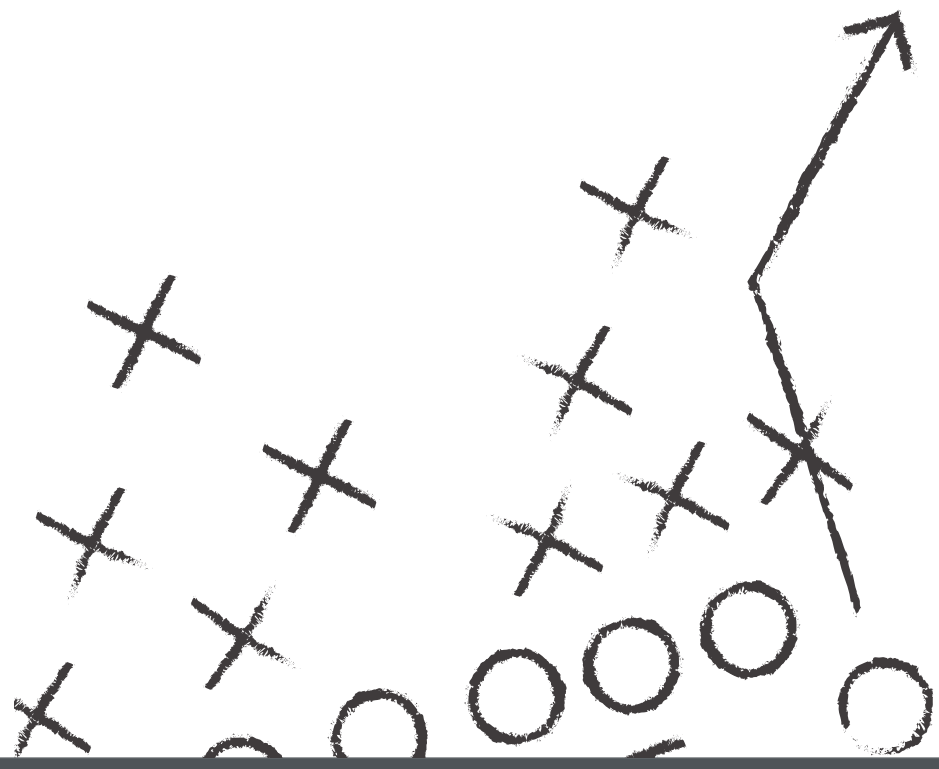
Integrating preoperative planning into a busy surgical practice can be challenging unless the surgeon can understand the benefits, both to themselves and to patients. For the surgeon, integration involves two major steps: having a discussion with the patient and assuring they obtain a CT scan and then actually planning the procedure. While I initially had some trepidation about asking patients to obtain a CT scan, especially when they already had x-ray and an MRI, I have not had many patients who were unhappy, particularly with how I frame the discussion. I emphasize how I can practice their shoulder replacement on a computer before performing the surgery, ensure I am using the appropriate implant, and dial in the optimal position for the implant to hopefully improve longevity. I have a pretty diverse patient population from a large geographical area, and neither of those have presented a significant challenge. Planning each individual case takes less than 10 minutes and the system automatically reminds me that a plan is needed.

I find the actual planning to be enjoyable, and always do it a minimum of 2 weeks before the planned surgery in case I identify more significant glenoid pathology that may require switching implant types.

Naturally, some surgeons will oppose obtaining a CT scan for patients or will not want to bother with planning. However, this is contrary to the national trend. Our recent study showed that in the past decade, there has been a more than 500% increase in the use of CT scans preoperatively for patients undergoing anatomic TSA, even outpacing MRI.[8] In my practice and among my close colleagues, a preoperative CT scan is essentially mandatory for all anatomic TSAs, as glenoid deformity is challenging to characterize on plain radiographs and patients for whom anatomic TSA is being planned often do not have MRIs.

CT scans have a huge added benefit for reverse shoulder replacements, but I don't consider them to be mandatory for patients with minimal glenoid deformity confirmed on a recent preoperative MRI. I still prefer to obtain a CT scan and use the VIP system for these patients, as I can correct superior inclination and optimize baseplate and central screw/post position, but I am less dogmatic about ordering them in these situations.

When discussing preoperative planning with surgeons who are currently not interested, focus on encouraging them to start with anatomic TSAs as it is rapidly becoming the trend nationwide.



Demonstrate

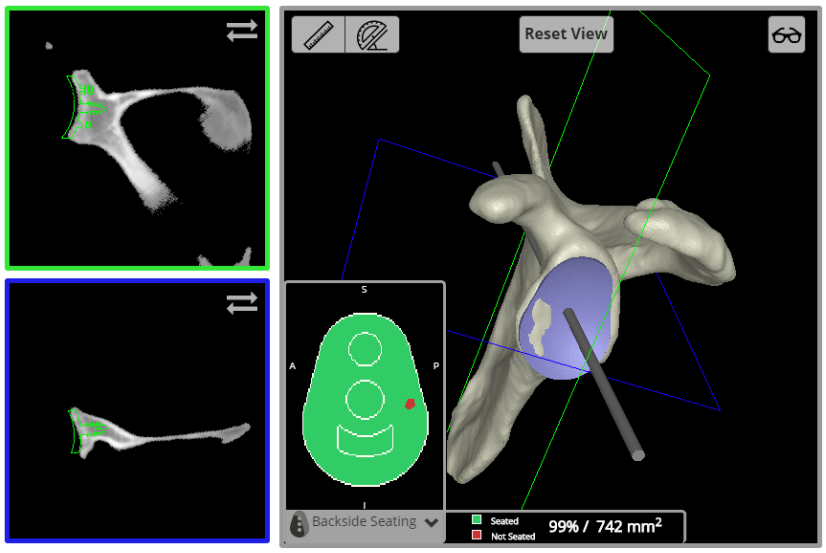
Surgeon's Perspective

VIP™ Planning Specifics and "Hot Topics"

There are several interesting and hot topics that are worth discussing regarding implant positioning with the VIP system. I'll highlight them individually.

Implant Version

There are several ways to measure version, or the angle of the glenoid, in the axial plane.[9] Friedman's method is the most common, but be aware that different vendors' systems have different methods for determining glenoid version and inclination. We'll discuss more of that later.



Correction of 14° of retroversion for an anatomic TSA with with 99% backside seating, preservation of subchondral bone, and final retroversion of 4°

- **Anatomic TSA:** For anatomic TSA, there are several important principles for glenoid component placement, several of which relate to version: (1) subchondral bone preservation,[10] (2) correcting to less than 10° of glenoid retroversion,[11] and (3) obtaining good bony support.[12] Whenever possible, I aim to correct the glenoid to neutral or near neutral version. This must be balanced with depth of reaming and backside support, but for cases with minimal or moderate retroversion, is usually very possible. It is important for Technology Consultants to remember that the planning engineers will always provide a plan corrected to 10° of retroversion if the native retroversion is greater than that; it is often easy to correct more, so surgeons should be reminded to do so.
- **Reverse TSA:** For reverse TSA, correcting retroversion is easier because preservation of subchondral bone is less important than for anatomic TSA. I generally attempt to restore neutral version, however, recent literature has shown that correcting to anywhere between 0°-5° of baseplate or glenosphere retroversion was optimal for achieving the best impingement-free range of motion.[13] The addition of the augmented MGS baseplate has made version correction for RSA even easier. With minimal reaming, even large deformities can be corrected with augments.

Demonstrate

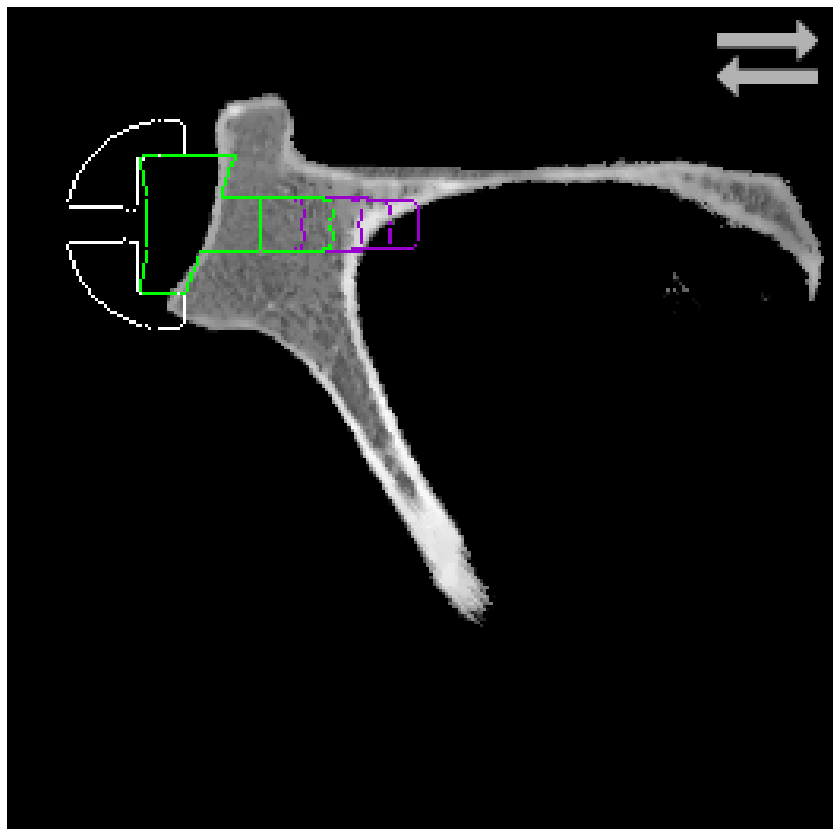
Surgeon's Perspective

Implant Inclination

Inclination has traditionally not enjoyed the same focus as version, particularly for aTSA, but has recently been the subject of more scrutiny. Particularly with the use of preoperative planning systems such as the VIP™ system, it has become much easier to recognize superior inclination of the glenoid and correct it more reproducibly. There are several methods of measuring glenoid inclination, with the beta angle being the most common and what I typically use.[14] The VIP system makes recognition of pathologic superior inclination and correction much easier for surgeons.

- **aTSA:** Increased glenoid component inclination in aTSA can lead to superior humeral head migration and additional stress on the rotator cuff. Traditionally, 10 degrees or less of superior inclination is considered acceptable for aTSA.[15] Biomechanical studies have supported these findings and have advocated for correcting inclination during TSA.[16] Our data looking at Arthrex TSAs (not yet published) has shown improved clinical outcomes when inclination is corrected to 10° or less, which is what I aim to do on all aTSAs.

- **rTSA:** Traditionally, inferior offset and inferior tilt of the baseplate have been recommended to avoid scapular notching. This has also been shown in biomechanical studies to improve impingement-free internal and external rotation.[17] Avoiding superior tilt is also important for avoiding postoperative instability and scapular notching.[18] With the lateralized MGS baseplate and glenosphere options as well as 135° humeral neck-shaft angle and inlay humerus, scapular notching is less of a concern and external rotation is restored more reliably.[19] Some biomechanical data also demonstrates that neutral tilt may be better for certain glenosphere geometries and positions.[20] Given this, I typically aim to correct the beta angle to near neutral, with a glenosphere that is flush or a millimeter or two below the inferior rim of the glenoid. Similar to version, the addition of the augmented MGS baseplate has made this even easier and minimized the amount of reaming required to achieve the desired baseplate and glenosphere position.



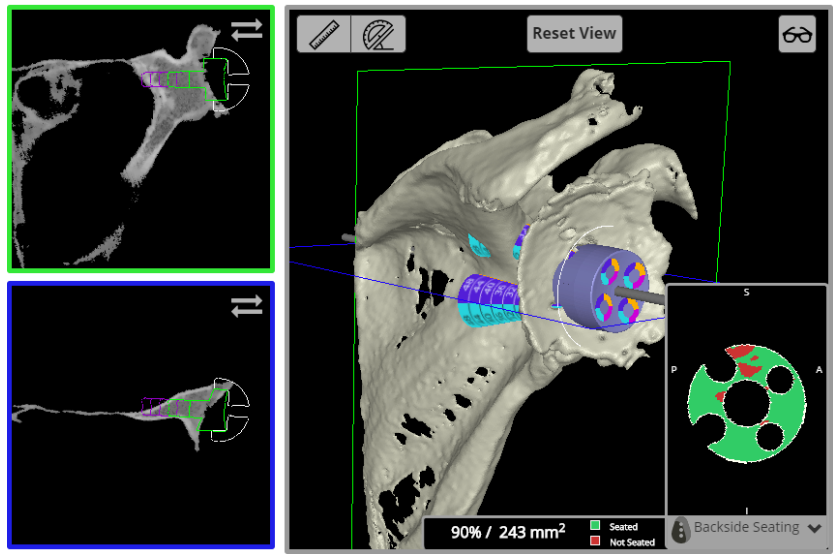
Correction of 19° of superior tilt using a 20° superiorly augmented MGS baseplate from the VIP system with minimal reaming

Demonstrate

Surgeon's Perspective

Backside Seating

Backside seating is a feature in the VIP™ planning software that is of considerable research interest to me. There is actually surprisingly little literature guiding surgeons to help dial in the appropriate balance of backside seating, version correction, and bony reaming, but I'll summarize my guidelines here.



Correction of 31° of retroversion using a 20° augmented MGS baseplate. Using the VIP system allowed for a plan that accomplished correction to 3° of retroversion with 90% backside seating and minimal medialization and reaming.

- **aTSA:** Traditional teaching was that 100% bony glenoid support was needed for polyethylene anatomic glenoid components. Given the need to preserve subchondral glenoid bone to avoid subsidence, 100% seating is not always possible.[10] A recent biomechanical study recommended 95% or more backside bony support, but the clinical translation of their findings were not definitive.[21] Clinical studies have found no loosening at midterm follow-up when there is at least 80% backside support.[12] I typically aim to maximize backside seating as high as possible, with a minimum of 90% as a balance between the findings from the biomechanical and clinical studies. It is likely that the design of the Univers VaultLock® glenoid and bony ingrowth centrally will allow the implants to remain stable even without 100% bony support.

- **rTSA:** For rTSA with baseplates like the MGS, biomechanical studies have shown that much less bony support can be tolerated without any increase in micromotion. Two recent biomechanical studies found that 50% or greater backside seating was sufficient for reverse TSA baseplates.[22,23] There is very little clinical literature to guide surgeons here, but I typically attempt to get at least 75%-80% backside seating for the MGS baseplate. Arthrex also offers numerous other options when there is significant deformity, including the augmented MGS baseplates. Augments allow me to maximize backside seating and version or inclination correction with minimal reaming.

Demonstrate

Surgeon's Perspective

Max Gap Offset

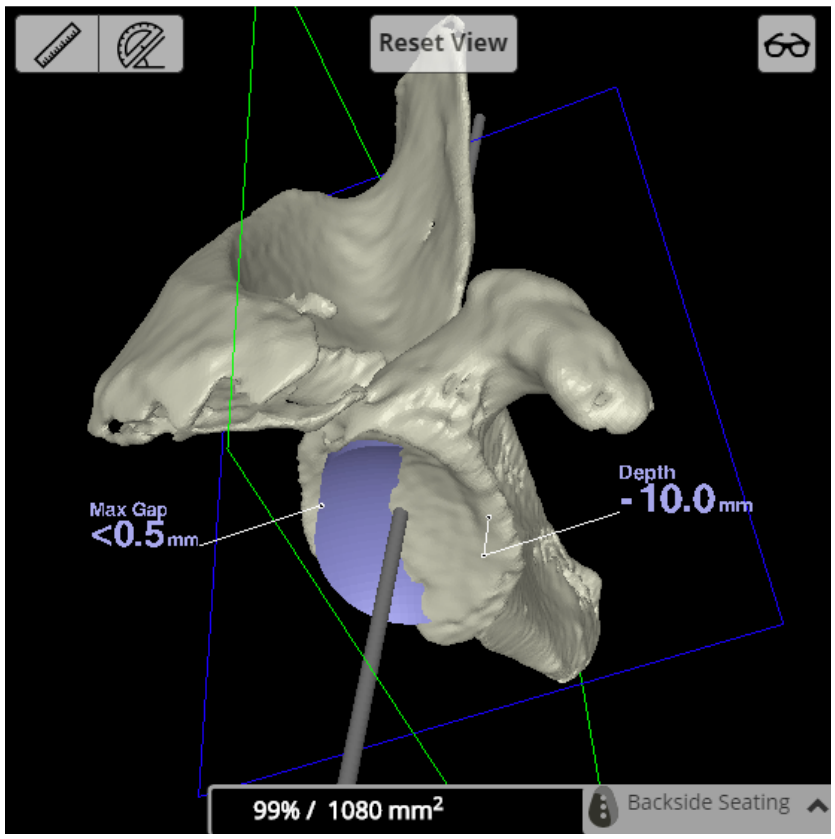
Max gap offset and depth measurement are two features in the VIP™ software. I find depth measurement to be the most useful, particularly for aTSA, to ensure I am not removing too much bone and violating the subchondral bone. Max gap offset can be useful in ensuring that, even in cases where there is not 100% bony support, there is minimal distance between the implant and bony surfaces.

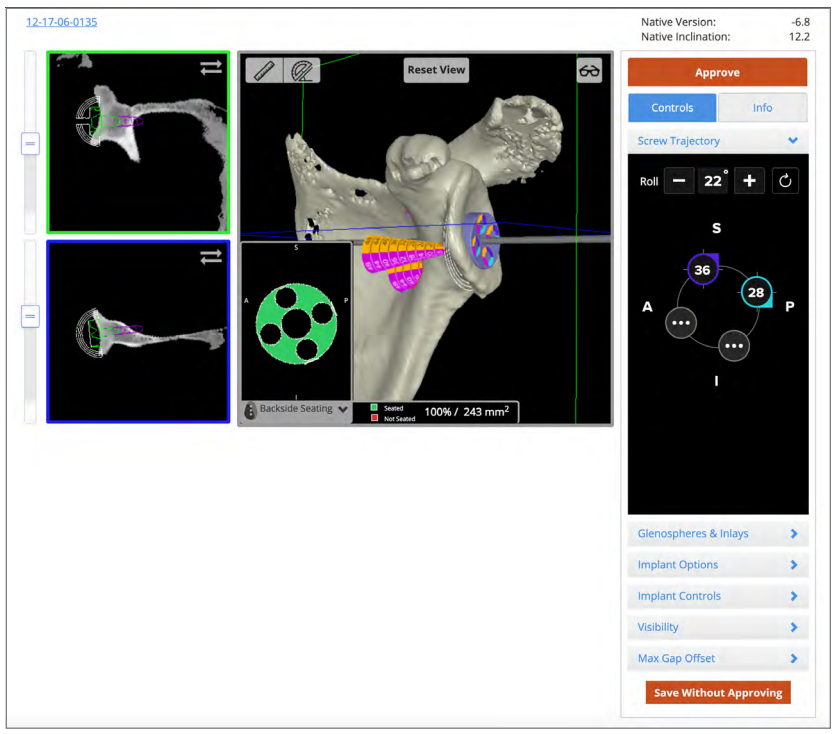
Both max gap offset and depth are helpful system additions for optimizing glenoid component placement.

Screw Trajectory

The VIP system's screw trajectory feature allows surgeons to more precisely determine screw length and will also help anticipate poor trajectories. The superior MGS baseplate screw can be the most concerning. The two important considerations are potential suprascapular nerve injury[24] and risk for scapular spine fracture.[25,26]

Prior to the release of this feature, I carefully measured the length of the screw and chose a size smaller than the measured length. Now with the screw trajectory option in the VIP system, I can view the approximate trajectory of a locking screw and, if it is concerning, I will plan for a nonlocking screw in that location with a more optimized trajectory.





Demonstrate

Surgeon's Perspective

What Differentiates VIP™ Planning From Other Systems?

Calculation of Version and Inclination

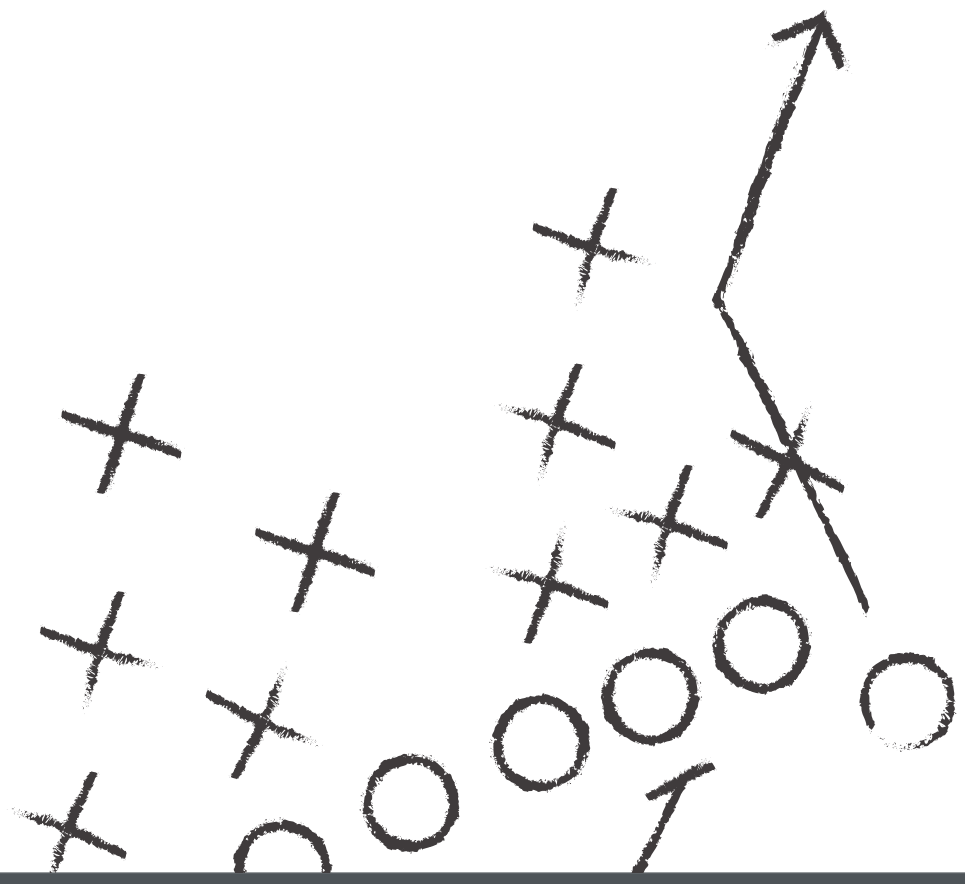
As you will see in this playbook and may already know, numerous competitors have CT-based planning software available. There are numerous fundamental differences between these systems, including how they calculate inclination and version. In our recent study, we found very limited agreement between four commercially available planning software systems for version, inclination, and humeral head subluxation.[27] This difference stems from how these measurements are calculated and what landmarks, if any, are used. The VIP system uses a manual landmark-based method to determine the scapular plane.[28] The transverse scapular line is then defined and version and inclination are determined based on the glenoid plane relative to the scapular plane, a method that was previously validated with external cadaveric measurements.[29] This is similar to several competitors, which will be described later. Other options include the glenoid vault model first described in 2008,[30,31] which is an automated method that creates a unique glenoid vault shape with varying sizes dependent on scapula size, and the "average scapula plane" used with the Blueprint™ software.

Humeral Subluxation

Humeral subluxation is an important characterization of how far the humerus sits posteriorly relative to the glenoid. Traditionally, significant static posterior subluxation was considered to be a relative contraindication for anatomic TSA due to the risk of postoperative posterior instability.[32] Measurement of posterior subluxation has traditionally been accomplished via 2D axial scans with demonstrated reliability. Two competitors' systems offer a measurement of 3D humeral head subluxation, which has not been validated to correlate with clinical outcomes after TSA. In general, these systems overestimate the percentage of posterior subluxation compared to surgeon measurements.[27] While it's a nice feature to have, the clinical significance is not clear, and it is easily characterized on 2D images without software.

Range of Motion (ROM)

The Blueprint software offers ROM capabilities, which is an intriguing addition. This theoretically allows surgeons to begin personalizing the implant type and position to optimize not just parameters on the scapula, but a theoretical patient outcome. This represents the "next frontier" of preoperative planning, but in its current existence, is not particularly beneficial. ROM output in the Blueprint software is "impingement-free ROM," which is the rough equivalent of what the implant will allow to happen, but obviously overestimates the actual final ROM the patient will achieve due to muscular forces or soft-tissue constraints not being accounted for.



Demonstrate

Surgeon's Perspective

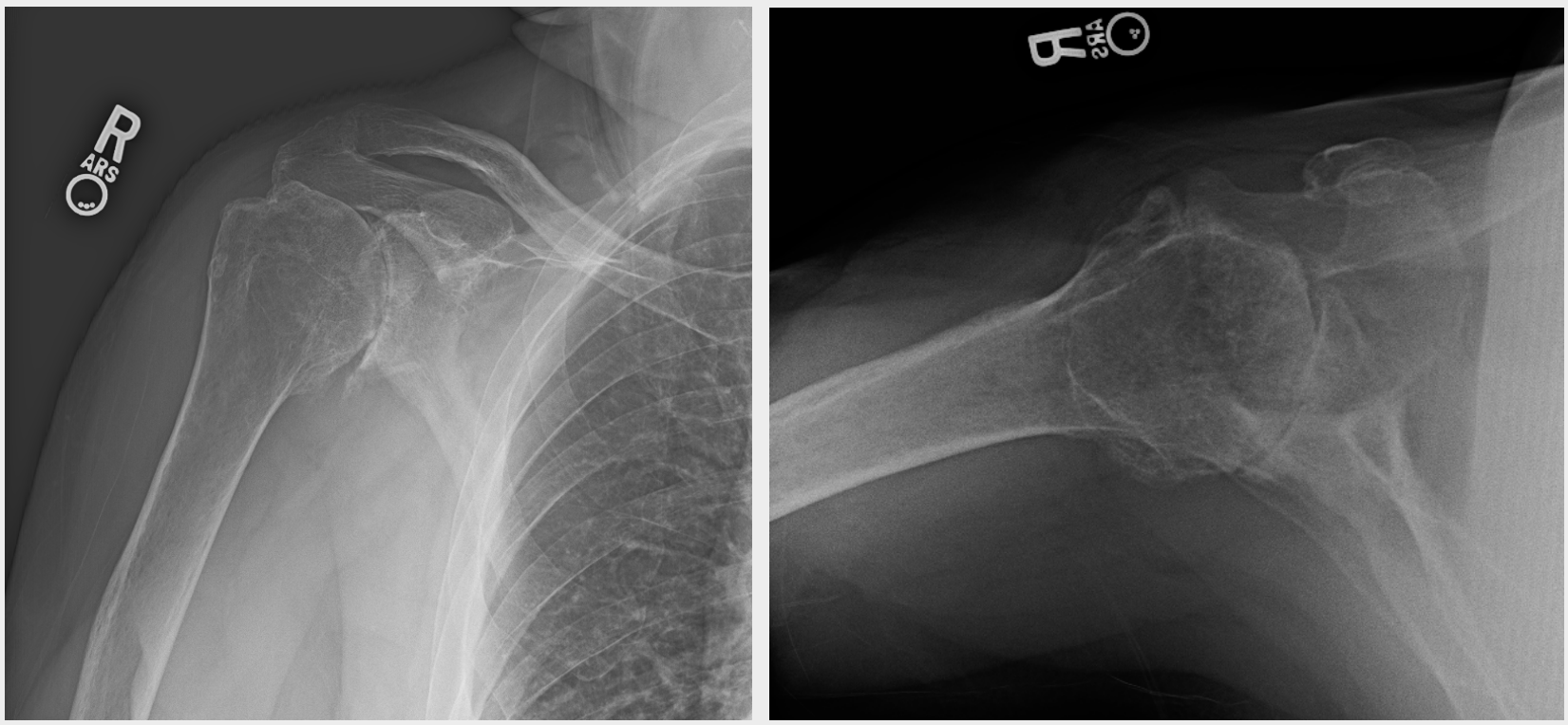
Weaknesses of the VIP™ System

While the VIP system is a strong technology, it has some weaknesses that merit discussion. The first, which is also a strength, is that it requires an engineer to produce an initial plan. Some competitors' systems (eg, ExactechGPS® shoulder), allow surgeons to make a plan immediately before scrubbing into the case, which saves them having to plan quite as far in advance. Second, unlike some competing systems (eg, ExactechGPS shoulder), screw trajectories cannot be transferred from the plan to the patient with the current targeter.

The Future of VIP and 3D Planning

3D planning will continue to evolve over the next decade. We are already seeing a rapid addition of functionality to the VIP system, including backside seating, screw trajectory, and augmented MGS baseplates. Within the next 5-10 years, planning will transition to creating a true virtual reality experience in the operating room. More importantly, 3D planning will begin implementing not only measurements of implant position on the scapula, but also patient clinical outcomes to understand how to individualize implant placement and achieve the best clinical outcomes for patients based on their individual pathology.

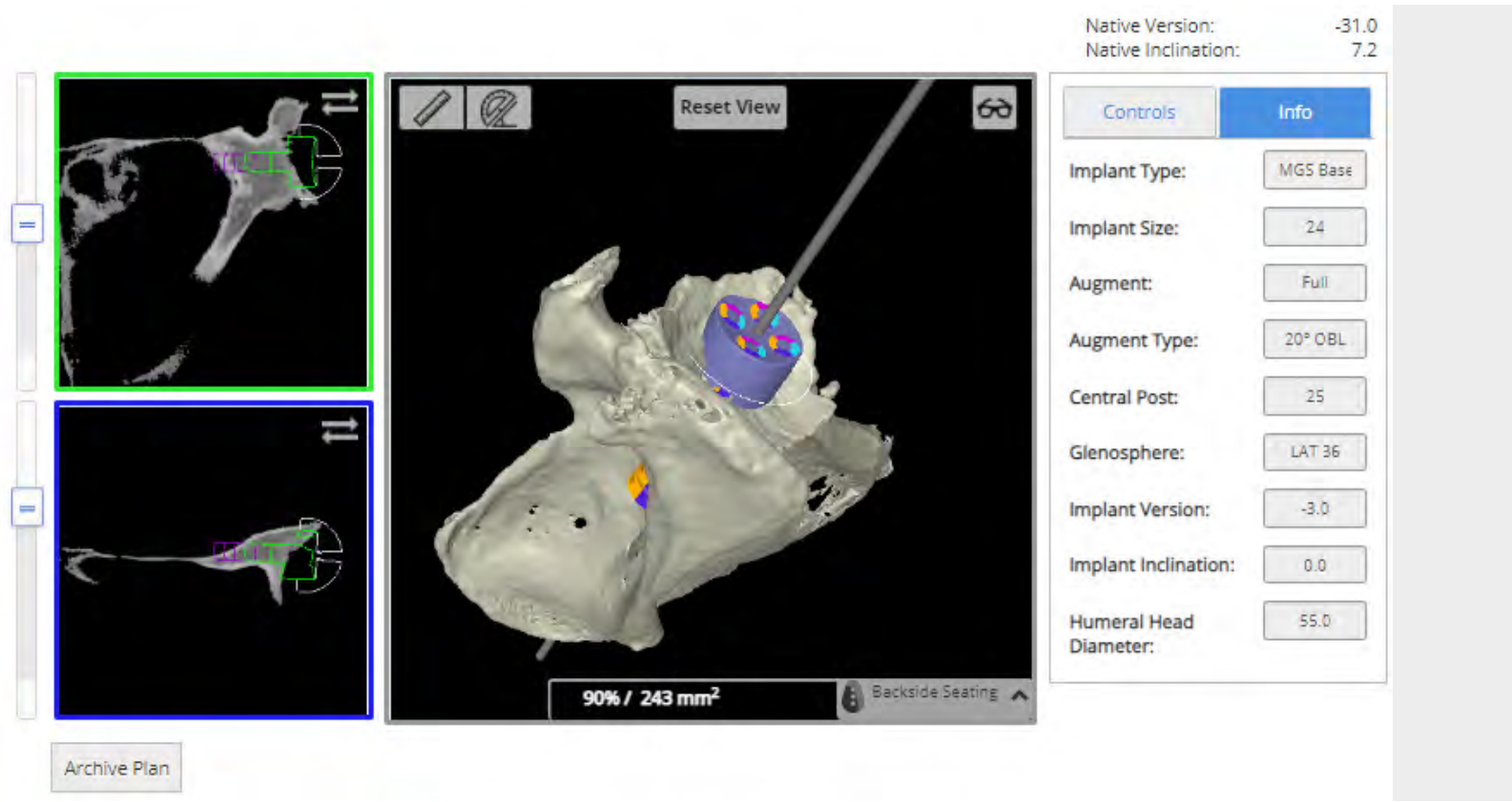
Case Presentation



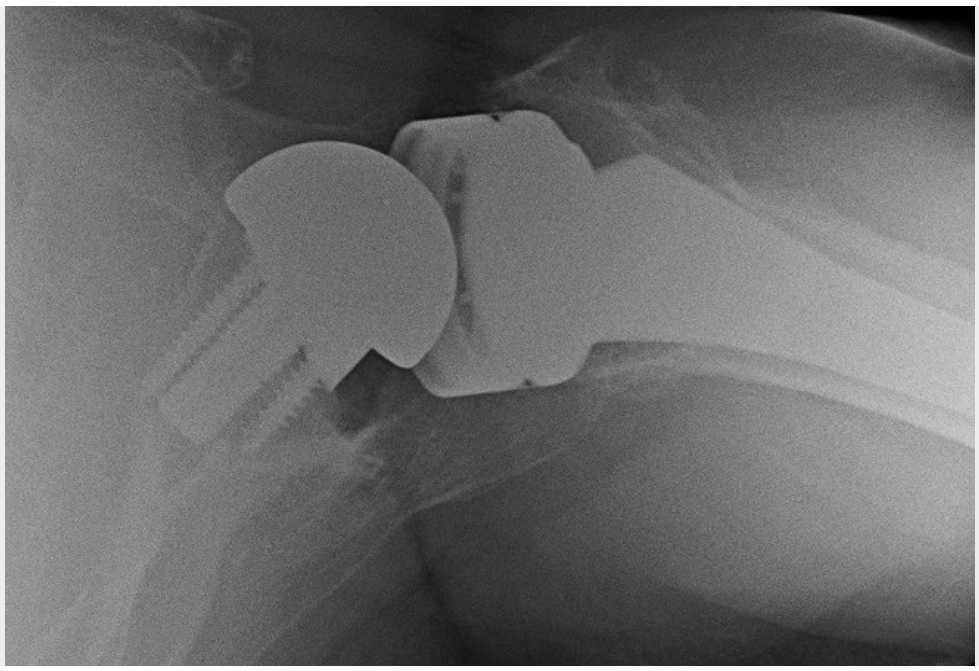
A 63-year-old patient with severe glenohumeral arthritis but preserved rotator cuff strength was planned for right aTSA. His x-rays demonstrated moderate retroversion that was amenable to eccentric reaming, but a CT scan was obtained prior to surgery to further evaluate the deformity.

Demonstrate

Surgeon's Perspective



Instead, the plan was changed in the VIP™ system to perform a posteriorly augmented MGS reverse. The case went quite well and the postoperative radiograph demonstrates excellent correction of his posterior deformity with a 20°, posteriorly augmented MGS baseplate.



Postoperative radiograph

Demonstrate

Key Features and Benefits

Anatomic	Implant/Features	Usage/Benefits
	Keeled Glenoid S, M, L, XL	■ Approximately 4% of all aTSA glenoid usage ■ Typically reserved for patients with smaller glenoid vaults and bailout for Univers VaultLock® glenoid
	Univers VaultLock Glenoid S, M, L, XL	■ Approximately 90% of all aTSA glenoid usage ■ Standard for aTSA with mild to moderate retroversion and appropriate glenoid vault for fixation
	Univers VaultLock Augmented Glenoid S, M, L, XL 15° and 25° half-wedge	■ New product released September 2021 ■ 15° and 25° half-wedge configuration ■ Used in aTSA with mild to moderate retroversion and appropriate glenoid vault for fixation
	Universal Glenoid Convertible Baseplate (CUG) S, M, L	■ Approximately 6% of all aTSA usage ■ Historically used in patients with glenoid retroversion, poor rotator cuff quality that may be revised to rTSA in the near future, or during a revision surgery with a contained glenoid vault defect ■ Can be used in conjunction with autograft bone
	Bone Graft Instrumentation Angle: 5°-35° Diameter: 0 mm-20 mm	■ Historically used in aTSA mild to moderate glenoid retroversion was encountered and polyethylene was not available ■ Limited use in aTSA with CUG and Univers VaultLock augmented glenoid
	Congruent Reamer Instrumentation Diameter: 40 mm-56 mm	■ "Ream and Run" hemiarthroplasty is used by surgeons when patients are not candidates for aTSA ■ Glenoid is reamed so the glenohumeral mismatch is appropriate when the humeral head is replaced
	Universal Glenoid Convertible Baseplate (CUG) S, M, L	■ Approximately 5% of baseplates used in rTSA ■ Original Univers Revers™ baseplate ■ Convertible from aTSA ■ Used with central, contained glenoid defects
	Standard MGS Baseplate 24 and 28 mm	■ Approximately 95% of baseplates used in rTSA ■ 24 mm monoblock screw/post ■ 24 mm and 28 mm modular screw/post ■ Fits smaller patient anatomies than the CUG ■ Available to use with bone graft instrumentation
	Oblique, Full-Wedge Augmented MGS Baseplate 10° and 20° 24 mm and 28 mm	■ 10° and 20° oblique, full-wedge configuration ■ 24 mm and 28 mm* diameters ■ Post option only ■ Optimal peripheral hole placement for superior-posterior bone defects
	Standard, Full-Wedge Augmented MGS Baseplate 10° and 20° 24 mm and 28 mm	■ 10° and 20° nonoblique, full-wedge configuration ■ 24 mm and 28 mm* diameters ■ Post option only ■ Optimal peripheral hole placement for purely superior or purely posterior bone defects
	Oblique, Half-Wedge Augmented MGS Baseplate 15°, 25°, and 35° 24 mm and 28 mm	■ 15°, 25°, and 35° oblique, half-wedge configuration ■ 24 mm and 28 mm* diameters ■ Post option only ■ Optimal peripheral hole placement for superior-posterior bone defects
	Standard, Half-Wedge Augmented MGS Baseplate 15°, 25°, and 35° 24 mm and 28 mm	■ 15°, 25°, and 35° nonoblique, half-wedge configuration ■ 24 mm and 28 mm* diameters ■ Post option only ■ Optimal peripheral hole placement for either purely superior or purely posterior bone defects

Demonstrate

Product Applications

The following case examples represent various scenarios and surgeon philosophies, and examine how to use Arthrex implants to address the presenting pathology. It is imperative to speak with surgeons to determine their personal algorithms for determining the most appropriate procedure based on aligned goals and outcome expectations. Preoperative planning with the VIP™ system allows you and your surgeons to position the appropriate implant based on the following glenoid classifications.

A1: Glenohumeral osteoarthritis or avascular necrosis minimal glenoid wear

For patients with an intact rotator cuff and minimal glenoid wear, aTSA is the most appropriate choice with an all-polyethylene glenoid (Univers VaultLock® glenoid > keeled glenoid). Augmented polyethylene, bone grafting, and rTSA are typically not chosen for these patients; Universal Glenoid™ convertible system may result in lateralizing the center of rotation, overstuffing the joint, and placing stress on the rotator cuff.

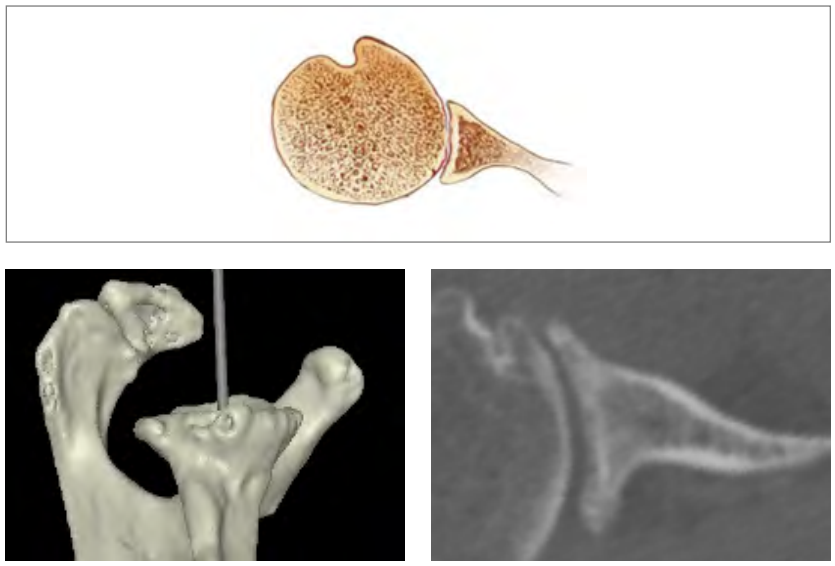


Fig. A1

A2: Glenohumeral osteoarthritis, inflammatory arthritis with higher degree of central glenoid wear/medialized joint line

For patients with an intact rotator cuff and more significant central glenoid wear, aTSA is the most appropriate choice with an all polyethylene glenoid (Univers VaultLock glenoid > keeled glenoid) or the Universal Glenoid convertible system (since the joint line may be medialized). These procedures should be planned in the VIP system to ensure proper joint line restoration. Augmented polyethylene, bone grafting, and rTSA are not typical treatment options.

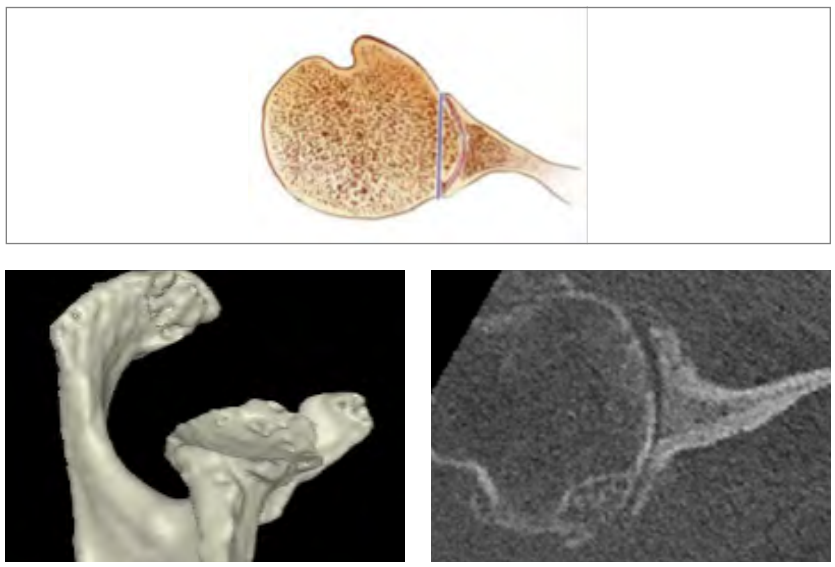


Fig. A2

Demonstrate

Product Applications

B1: Glenohumeral osteoarthritis or inflammatory arthritis with higher degree of posterior glenoid wear with or without a medialized joint line; humeral head may show posterior subluxation
For patients with an intact rotator cuff and more significant posterior glenoid wear (version of 10°-20°), aTSA with an all-polyethylene glenoid (standard or augment) or CUG is an appropriate treatment. Determine surgeons' philosophy on "respecting the version" and not correcting the retroversion; using an augment; or correcting the version and using a standard all-polyethylene or CUG.

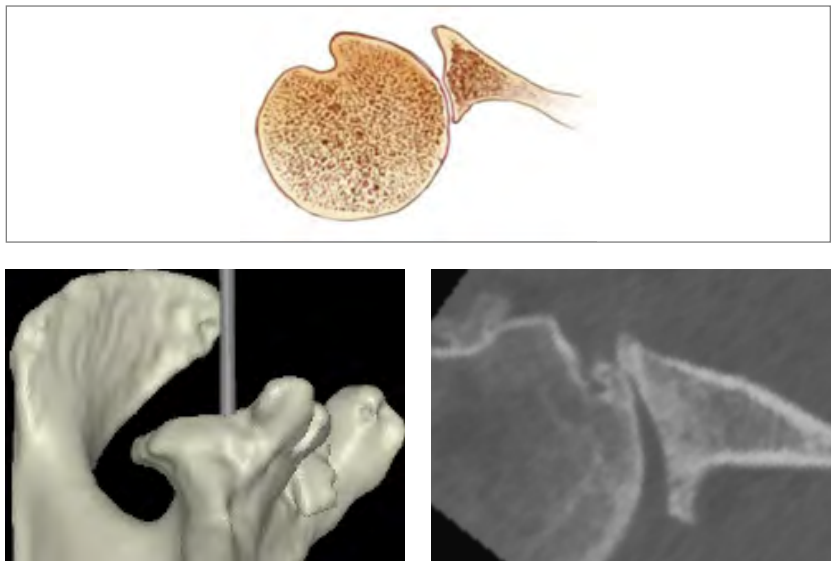


Fig. B1

Alternatively, for patients who have a questionable rotator cuff or a glenoid that is not amenable to an aTSA glenoid implant, rTSA is appropriate, either with a standard MGS (if correcting the retroversion) or an augmented MGS (either half- or full-wedge if respecting the version and not wanting to ream more glenoid). These cases should be planned using the VIP™ system to determine the best backside seating and appropriate joint restoration.

B2: Glenohumeral osteoarthritis or inflammatory arthritis with higher degree of posterior glenoid wear with or without a medialized joint line; humeral head may show posterior subluxation with a classic "biconcave" glenoid shape
For patients with an intact rotator cuff, more significant posterior glenoid wear (version of 20°-40°), aTSA with an all-polyethylene glenoid (standard or augment) or CUG is an appropriate treatment. Determine surgeons' philosophy on "respecting the version" and not correcting the retroversion, using an augment, or correcting the version and using a standard all-polyethylene glenoid or CUG.

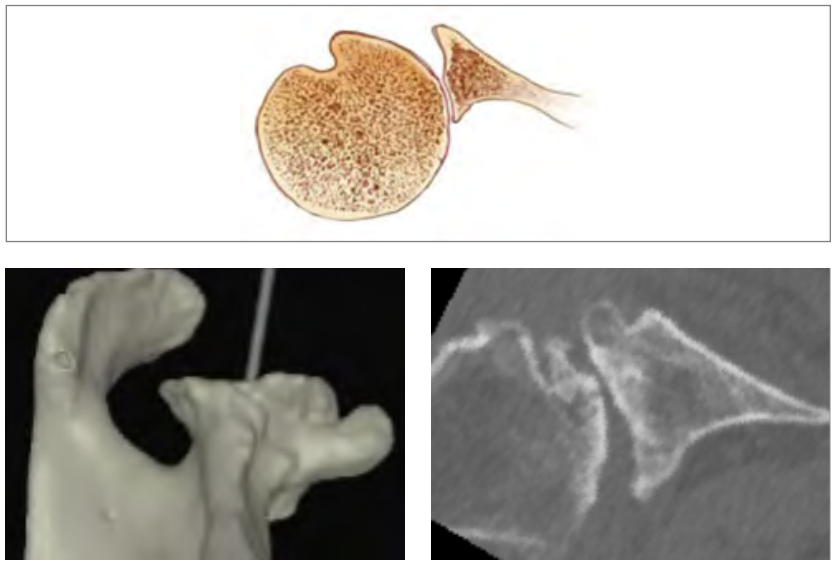


Fig. B2

Alternatively, for patients who have a questionable rotator cuff or a glenoid that is not amenable to an aTSA glenoid implant, rTSA is appropriate, either with a standard MGS (if correcting the retroversion) or an augmented MGS (either half- or full-wedge if respecting the version and not wanting to ream more glenoid bone). These cases should be planned in the VIP system to determine the best backside seating and appropriate joint restoration.

Demonstrate

Product Applications

B3: Glenohumeral osteoarthritis or inflammatory arthritis with higher degree of posterior glenoid wear with or without a medialized joint line; humeral head shows posterior subluxation and the glenoid is uniconcave

For patients with an intact rotator cuff and more significant posterior glenoid wear (version of >25°), aTSA with an all-polyethylene glenoid (standard or augment) or CUG is an appropriate treatment. Speak with your surgeon to determine their philosophy on “respecting the version” and not correcting the retroversion, using an augment, or correcting the version and using a standard all-polyethylene glenoid or CUG.

Alternatively, for patients who have a questionable rotator cuff or if a glenoid is not amenable to an aTSA glenoid implant, rTSA is appropriate, either a standard MGS (if correcting the retroversion) or an augmented MGS (either half- or full-wedge if respecting the version and not wanting to ream more glenoid bone). These cases should be planned using the VIP™ system to determine the best backside seating and appropriate joint restoration.

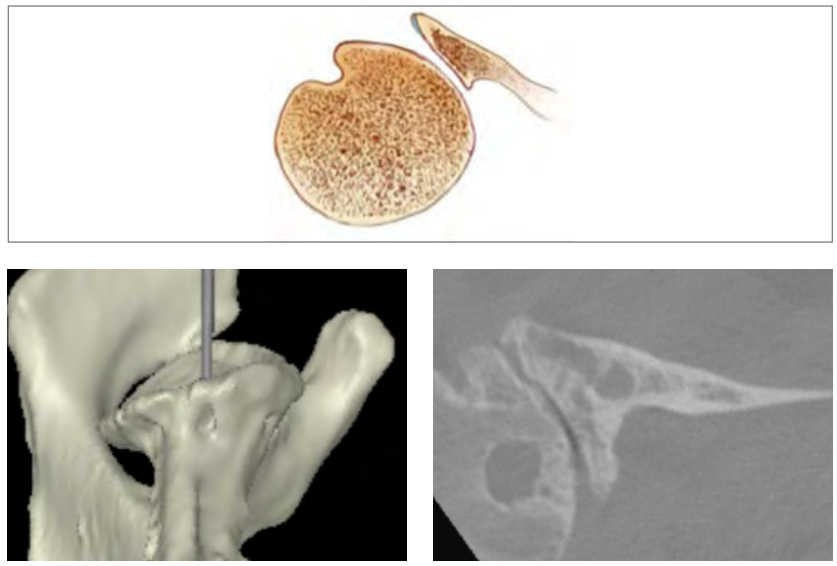


Fig. B3

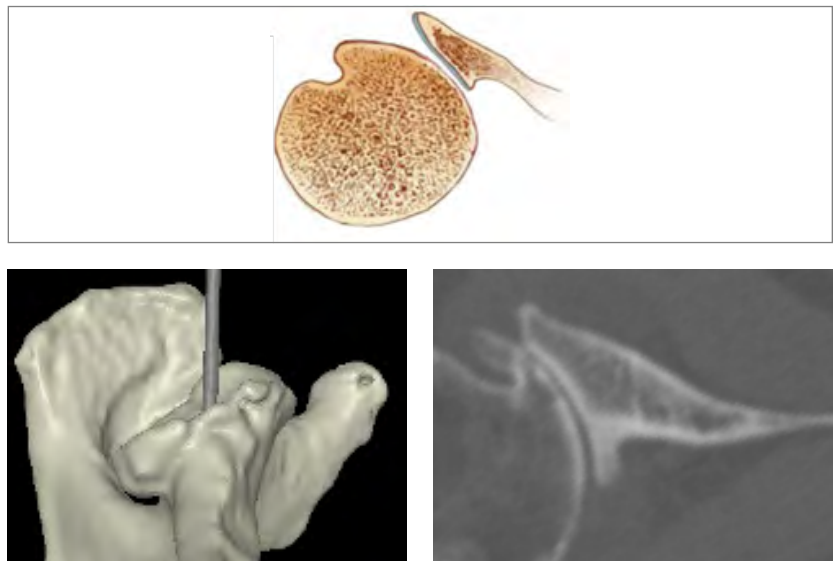


Fig. C

Demonstrate

Product Applications

D: Glenohumeral osteoarthritis with glenoid anteversion or anterior bone loss/humeral head subluxation (<40%); typically due to chronic anterior glenohumeral instability after dislocation/subluxation injuries

This pathology is not common due to the effectiveness of arthroscopic and open glenohumeral stabilization procedures. For a patient with an intact rotator cuff, aTSA may be appropriate if the remaining glenoid can accommodate an all-polyethylene implant. Alternatively, a CUG can be used with corrective reaming since the glenoid vault can accommodate the implant. For more complex pathology, including this pathology with a questionable or torn rotator cuff, rTSA may be more appropriate with an augment placed in an anterior position. It is important to ensure that the anterior subluxation isn't due to subscapularis dysfunction/tear. If so, rTSA is appropriate. These cases should be planned appropriately using the VIP™ system to ensure adequate bone stock for the chosen implant.

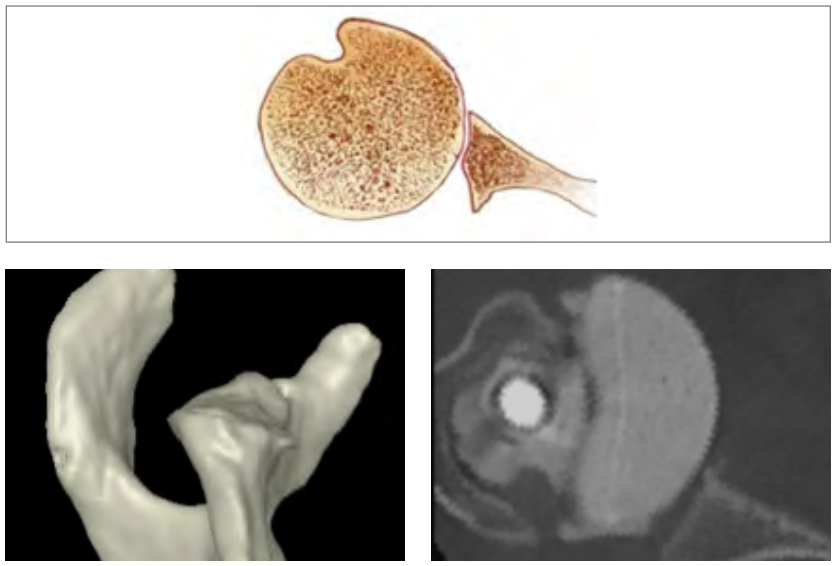
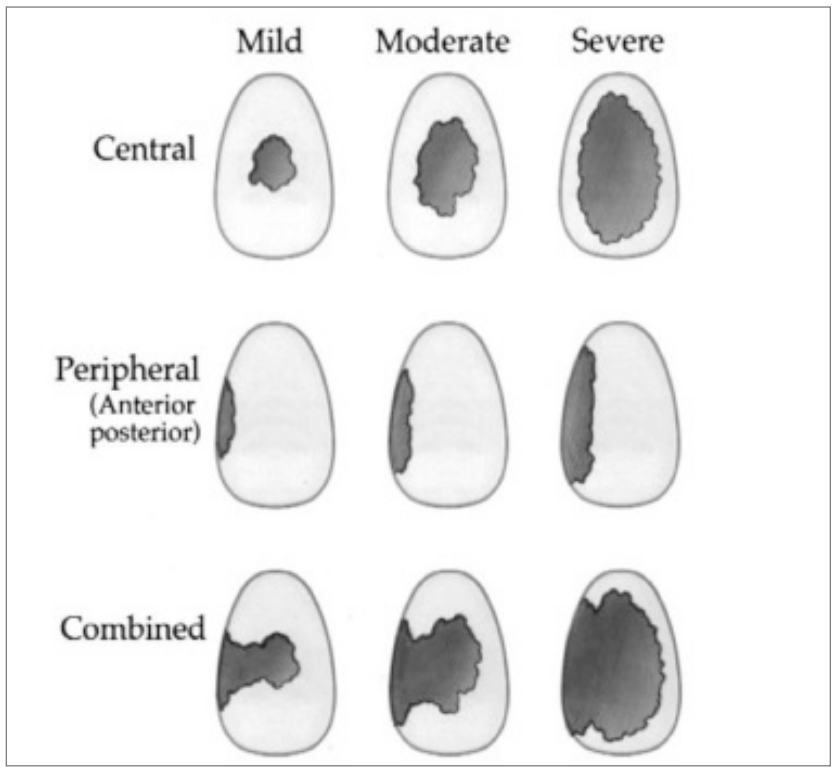


Fig. D

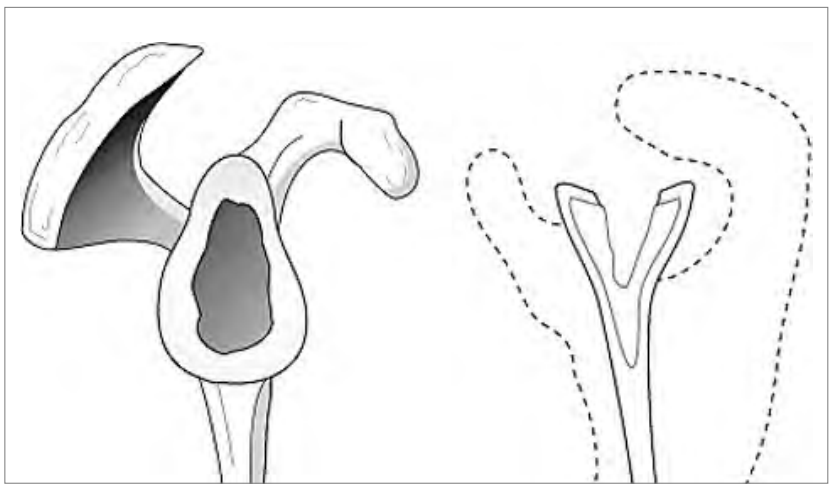
Demonstrate

Revision/Genoid Defects

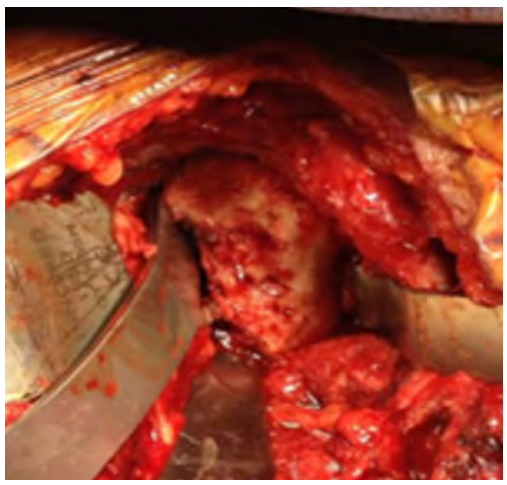
Complex glenoid pathology can be a complication of previous surgery, whether it's arthroscopic stabilization (“postage stamp” fracture), aTSA, or rTSA. The resultant deficiency in the glenoid vault can be classified as either contained or uncontained. Contained defects typically demonstrate bone loss centrally, while uncontained defects occur on the periphery of the glenoid. A defect can also be classified as combined, with central and peripheral defects.



A defect is considered contained if the bone loss is central and has glenoid bone on all sides. This type of defect can be managed with autologous impaction bone graft, typically from the iliac crest (hip) or allograft if the iliac crest is not available.



An uncontained defect is defined as one that does not have bone surrounding the entire defect. Impaction bone grafting is not a good option for these patients. Tricortical iliac crest bone graft (autograft), humeral head (if available, autograft), femoral head (allograft), augmented glenoid, or rTSA are all treatment options for uncontained glenoid defects.

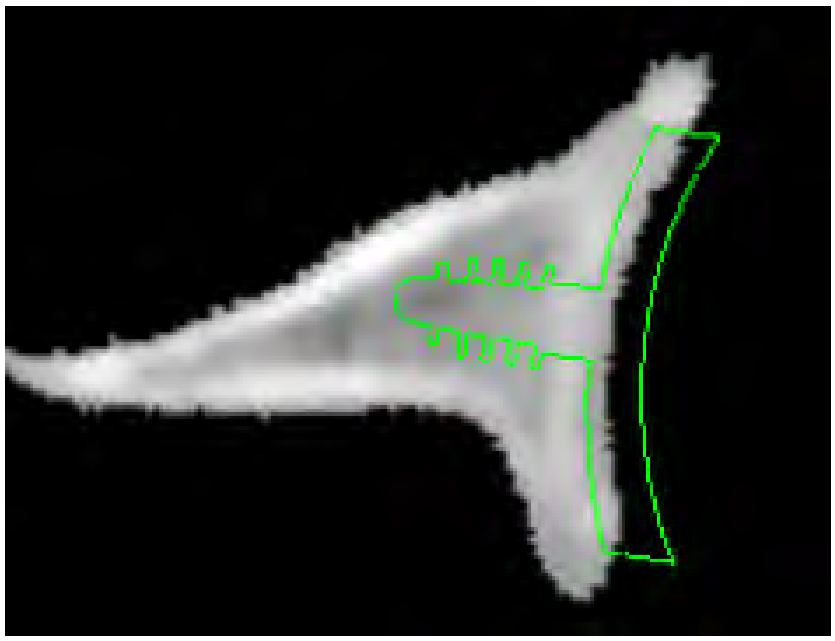


Demonstrate

Implant Positioning Concepts

As a reminder, not all implants are appropriate for all pathologies. Consider the following when planning cases:

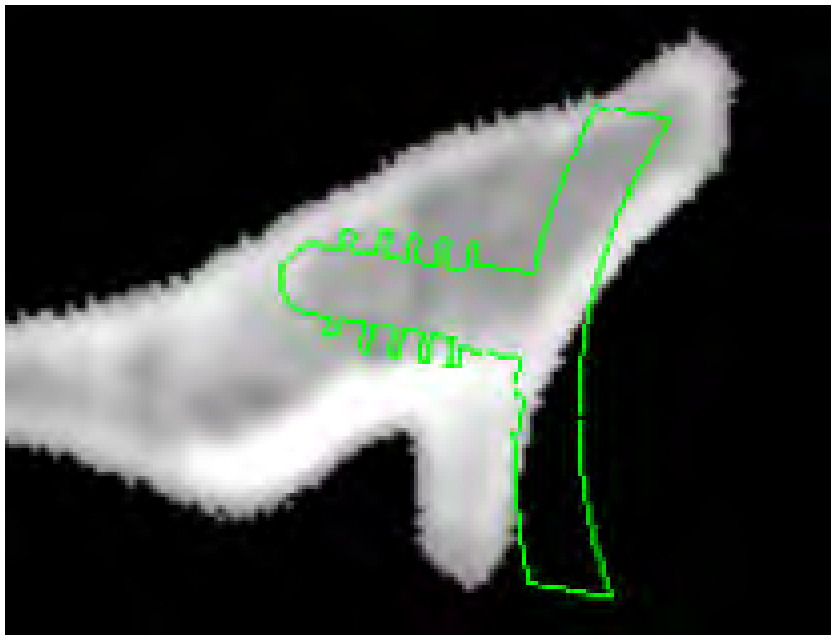
Glenoid Vault Depth
Glenoid vault depth is more important in aTSA than rTSA. Medialized, smaller glenoid vaults can be due to either wear or eccentric/high-side reaming and can pose a significant issue in aTSA. Ensure that the depth of the glenoid vault is enough to contain all of the polyethylene and CUG central boss backside components without perforation. In rTSA, surgeons may opt to place either the Univers Revers™ Modular Glenoid System (MGS) post or MGS central screw bicortical for stability.



Glenoid Vault Depth

Implant Version/Correction Reaming
Different philosophies exist when determining best treatment options for abnormal glenoid pathology: “respecters” versus “correctors."

“Respecters” are not inclined to ream a significant amount of anterior glenoid bone in order to achieve native anatomic version (0° to -10° of retroversion). Minimal glenoid reaming is expected and the implant, either aTSA or rTSA, will be placed in the altered anatomy. Conversely, “correctors” will ream the anterior glenoid to correct retroversion to a more native anatomic measurement (0° to -10° of retroversion). In the case of "correctors," it is important that the surgeon understands the glenoid vault depth as they are selecting their implant.

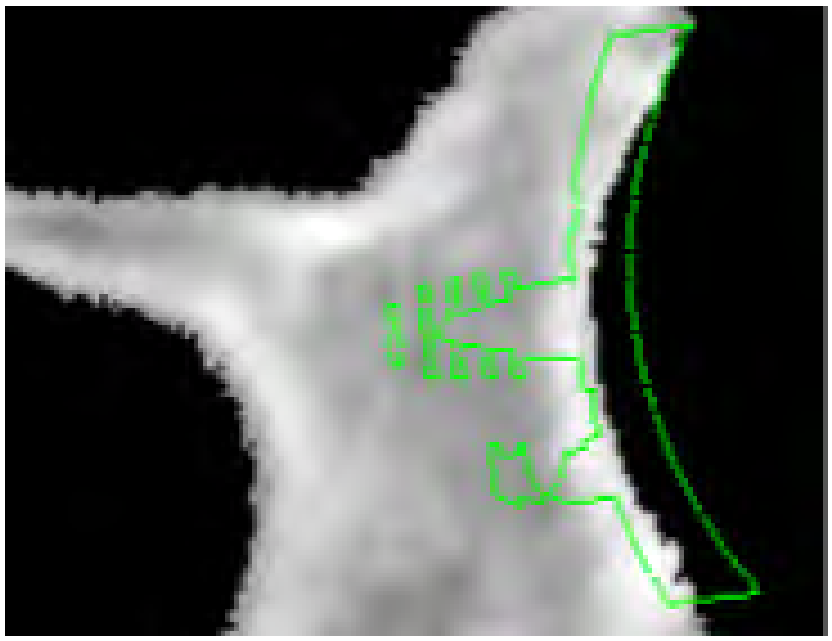


Implant Version/Correction Reaming

Demonstrate

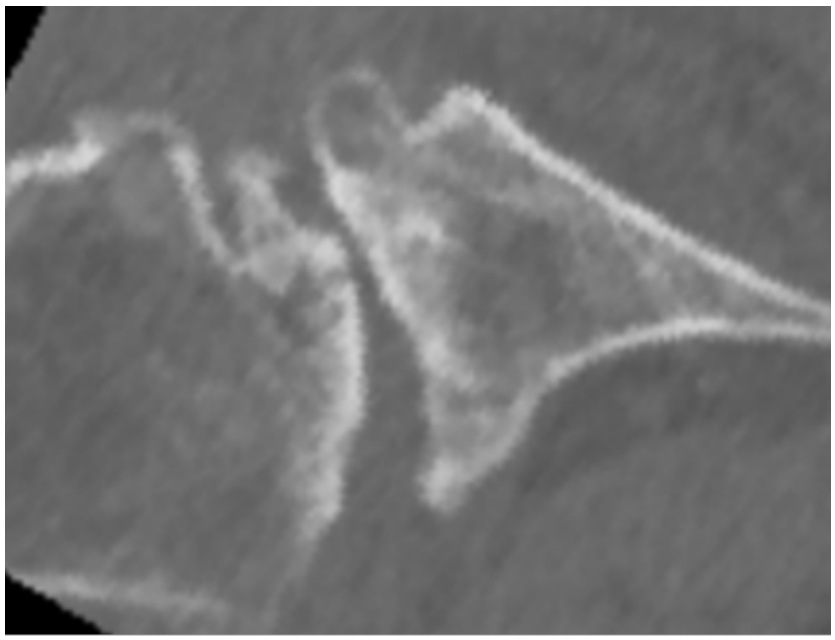
Implant Positioning Concepts

Implant Inclination
Native glenoid inclination is typically between 0°-10° of superior inclination. Implantation of both aTSA and rTSA should mimic native inclination as to not place abnormal forces on the superior portion of an all-polyethylene glenoid component, which causes an inferior-superior rocking horse.



Implant Inclination

Glenoid Bone Density
Glenoid vault bone quality should be assessed preoperatively to determine if an implant will achieve appropriate fixation. This is more important in nonscrew fixation implants like all-polyethylene components in aTSA, as decreased bone density can affect the stability and overall longevity of these implants. Glenoid cysts may also give the appearance of 100% backside seating around the periphery of the implant, without central peg seating. This may also be indicative of central peg perforation. Additionally, for patients who underwent rTSA and have decreased bone density, trauma can have a disastrous affect (eg, comminuted glenoid fractures). For rTSA, surgeons may opt for locking screws versus compression screws in patients with cystic changes or decreased glenoid vault bone density.



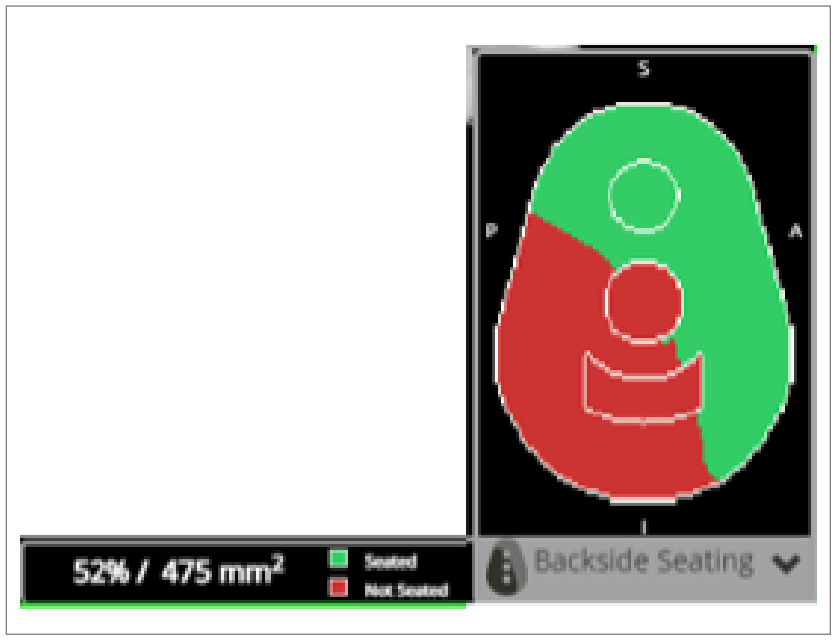
Glenoid Bone Density

Demonstrate

Implant Positioning Concepts

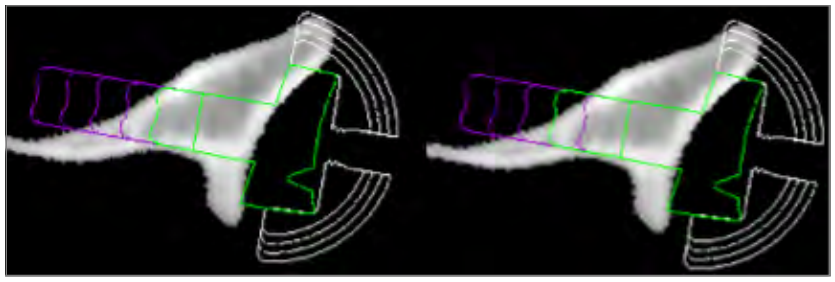
Implant Backside Seating

Determining the backside seating, or bone foundation, for implants is simplified with the use of the VIP™ system. An overall percentage and volume is provided in the plan. For aTSA, 100% backside seating is recommended. Glenoid cysts or peg perforation may appear as peripheral implant backside coverage without peg coverage. For rTSA, backside seating of 75%, or even as low as 50%, has been reported in the literature.[33] This can be accomplished through implant medialization or use of augmented implants or bone grafting, and is surgeon dependent. Discuss each of these scenarios with your surgeons prior to presenting the entire portfolio and planning cases.



Unicortical vs Bicortical Implant Fixation

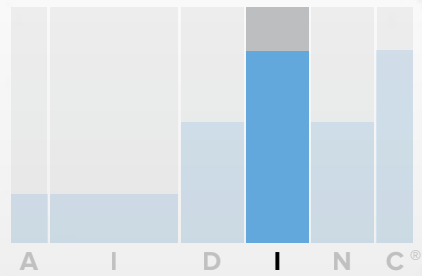
Unicortical versus bicortical fixation applies only to rTSA. A subset of surgeons will place the central post/screw through the medial portion of the vault, exiting the scapula anteriorly, for bicortical fixation. Alternatively, some surgeons will keep the central post/screw unicortical within the vault and save bicortical fixation for a revision scenario. Discuss each of these scenarios with your surgeons prior to presenting the entire portfolio and planning cases.



Validate

Action Guides™

- **Develop** trust and confidence in yourself, your products/procedures, and Arthrex.
- **Define** customer value.
- **Differentiate** the value you provide.
- **Provide** proof and evidence to support your claims.



For further information, see the **ECI Reference Guide**.

Peer-Reviewed Literature

1. Denard PJ, Hsu JE, Whitson A, Neradilek MB, Matsen FA 3rd. **Radiographic outcomes of impaction-grafted standard-length humeral components in total shoulder and ream-and-run arthroplasty: is stress shielding an issue?** *J Shoulder Elbow Surg.* 2019;28(11):2181-2190. doi:10.1016/j.jse.2019.03.016

2. Magosch P, Lichtenberg S, Tauber M, Martetschläger F, Habermeyer P. **Prospective midterm results of a new convertible glenoid component in anatomic shoulder arthroplasty: a cohort study.** *Arch Orthop Trauma Surg.* 2021;141(5):717-724. doi:10.1007/s00402-020-03454-y

3. Dillon MT, Chan PH, Prentice HA, Burfeind WE, Yian EH, Singh A, Paxton EW, Navarro RA. **The association between glenoid component design and revision risk in anatomic total shoulder arthroplasty.** *J Shoulder Elbow Surg.* 2020;29(10):2089-2096. doi:10.1016/j.jse.2020.02.024

4. Denard PJ, Gobezie R, Griffin JW, Romeo AA, Lederman E. **Osseous integration of the central peg of an all-polyethylene glenoid With 3 different surgical techniques.** *Orthopedics.* 2020;43(5):278-283. doi:10.3928/01477447-20200721-04

Validate

Competitive Matrix

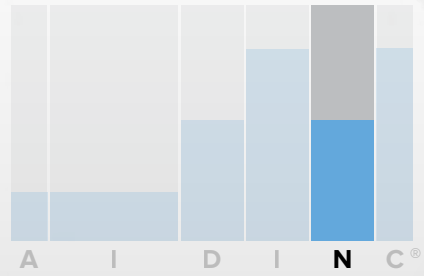
Manufacturer	Implant	Material	Shape	Variable Backside Curvature
Stryker/Tornier	ReUnion	All polyethylene	Keel Peg	
Wright	Aequalis™ Perform™+	All polyethylene	Keel Peg Cortiloc 15°, 25°, 35° half-wedges	Yes
Zimmer Biomet	Comprehensive®	Vitamin E	Convertible, metal-backed	
Zimmer Biomet	Alliance™	All polyethylene Hybrid center peg	Keel Peg	
DePuy Synthes	Global Unite®	All polyethylene	Keel Anchor peg StepTech (+3 mm, +5 mm, +7 mm step/augment)	
Exactech	Equinoxe®	All polyethylene Hybrid center peg	Keel Peg 8° and 16° augment	
DJO	AltiVate®	Vitamin E	Peg	
Catalyst	CSR	All polyethylene	Peg 10° augment	

Negotiate

The ACR System

- **Acknowledge** – Listen emphatically and nondefensively
- **Clarify** – Understand the objection and identify additional concerns
- **Respond** – Respond with relevant data or additional information

For further information, see the **ECI Reference Guide**.



Clinical Objections

Arthrex doesn't have vitamin E polyethylene implants.
Polyethylene wear in the shoulder is dissimilar to that of the hip and knee. No published studies have shown significant advantages of vitamin E polyethylene in the shoulder. In aTSA, glenoid loosening is more of an issue than polyethylene wear. The changing backside radius of curvature of the Univers VaultLock® glenoid significantly reduces radiographic and clinical loosening.[28] The Universal Glenoid™ convertible baseplate has also demonstrated excellent clinical and radiographic outcomes without excessive polyethylene wear and without implant loosening; it can also easily convert to rTSA, if necessary.[29] In rTSA, vitamin E-impregnated polyethylene cups may have a role, but with an inlay, lateralized, 135° neck-shaft angle, scapula notching is diminished and polyethylene wear is minimized.[30-32]

The VIP™ system doesn't include ROM, COR, or humeral planning.
Restoring COR and kinematics/biomechanics is of the utmost importance in aTSA, and is gaining more support in rTSA. As such, the VIP system currently includes native COR for rTSA without associated humeral planning. However, this point can be determined in aTSA by viewing the original CT scan and placing the glenoid component accordingly. Additionally, COR (for aTSA and rTSA), humeral planning, and impingement-free ROM will be available in the VIP system in 2023.

Arthrex doesn't offer polyethylene-metal hybrid aTSA glenoid implants.
The latest generation of fluted, all-polyethylene glenoid implants have demonstrated similar radiographic and clinical loosening rates compared to polyethylene-metal hybrids.[28,34] Additionally, all-polyethylene implants do not cause glenoid bone loss and potential central cavitary defects that polyethylene-metal hybrids with ingrowth may cause in revision surgery. If there is questionable glenoid vault bone, and the glenoid is medialized, the Universal Glenoid™ convertible baseplate is a better option than polyethylene-metal hybrid glenoids.

Negotiate

Clinical Objections

Arthrex doesn't offer a convertible system with MGS.

Background

Shoulder implants have evolved over many years. First-generation implants had monoblock humeral components that did not fit most patients' anatomy. In the early 1990s, humeral component modularity was introduced to address this issue. However, unlike their predecessors, they were not cemented and as a result were not perfectly aligned to the humeral head anatomy. Overstuffing of the glenohumeral joint was common. This lead to poor translation and limited ROM and putting undesirable stresses on the glenoid, which resulted in glenoid components loosening and rotator cuff complications. In the late 1990s, implants were introduced that accounted for the complex anatomy of the proximal humerus. These 3rd-generation implants restored the COR accurately, producing normal biomechanics and kinematics. The Univers Apex humeral stem is an advanced 3rd-generation implant.

"Convertible" implants are commonly referred to as 4th-generation implants. They incorporate some of the features of advanced 3rd-generation implants, but lack the ability to accurately replicate the humeral anatomy and restore the normal COR.

Fourth-generation implants incorporate modular "platforms," providing surgeons with intraoperative flexibility to implant stems in different ways for different conditions. Surgeons can choose different stem lengths, short or long, or even stemless. They can perform either an anatomic or reverse procedure and, if a revision is needed, convert an anatomic arthroplasty without removing the stem. Prior to the introduction of short stem and stemless implants, revision of standard porous-coated or cemented stems was considered very invasive, risky, and time consuming. Stem removal challenges fueled the appetite for convertible implants that did not require removal.

Other benefits of 4th-generation implants include: reduced blood loss, decreased OR time for revision cases, fewer complications specifically related to humeral component removal, and preservation of valuable humeral bone stock at the time of revision.[35-37]

Conversely, short-stem and stemless implants were designed to be more bone-conserving, which will make revision from aTSA to rTSA quicker and easier since more native bone should be available. The one caveat is that they were designed to be more anatomic than modular 4th-generation implants, and they are. The Univers™ Apex implant is an advanced 3rd-generation design intended to reproduce the normal anatomy, restore the native COR, and produce normal shoulder biomechanics and kinematics. At the same time, it preserves valuable diaphyseal bone stock and facilitates implant removal with little or no issue. If a revision is needed, the Univers Apex trunnion can be removed, facilitating access to the short humeral body making stem removal simple and predictable with standard OR instrumentation. Clinically, there is very little difference between a good anatomic short stem like the Univers Apex stem and a stemless implant like the Eclipse™ system. The most notable difference is the more bone-preserving nature of the Eclipse implant and the more reliable and robust subscapularis repair options of the Univers Apex implant.

As mentioned before, 4th-generation implants incorporate some, but not all of the design aspects of an advanced 3rd-generation short-stem and stemless implants. The ability to replicate the normal anatomy with 4th-generation implants is limited because they typically do not account for all anatomic offsets and angles of the normal humeral anatomy. Decisions on stem orientation may also need to consider rTSA principals versus relying solely on the anatomical parameters. The pitfalls for 4th-generation platform stems

include: overstuffing or insufficient tensioning of the glenohumeral joint with inadequate force couplings and deltoid muscle tension, excessive arm lengthening, suboptimal stem orientation (version and height) that prohibits consistent impingement-free ROM, and stem removal due to the inability to adequately introduce the onlay component with acceptable soft-tissue balance. Finally, there is no long-term data to support using 4th-generation implants.

The idea of convertibility is a good one but 4th-generation implants have considerable limitations that offset their advantages and because of this, they need to evolve. In almost all instances, they are onlay platforms. The next generation of convertible implants should strive to restore the normal anatomy better than its predecessors while allowing for more biomechanically correct conversions to reverse. This will require a movement from conversion on top of the humeral head cut (onlay) to conversion inside the humerus (inlay). The Global Unite® implant (DePuy Synthes) is an inlay implant. However, conversion inside the humerus is technically demanding, time consuming, and invasive, and the DePuy Synthes offering is no exception. With that in mind, R&D will continue to innovate and develop biomechanically sound convertible implants where conversion happens below the humeral head cut.

Response

After using the background to add context, present the key benefits of the Univers Apex and Eclipse™ systems: simple, predictable, minimally invasive implant removal (for both implants), and superior ability to restore the normal anatomy and COR for superior biomechanics and kinematics. Then present the biomechanical advantages of the Univers Revers™ system's 135° neck-shaft angle and the MGS glenosphere offset options for impingement-free ROM, mitigating scapula notching, and improving overall post-op ROM.

Takeaway

The advantages of a 4th-generation convertible stem are offset by its limitations and the compromises are just not worth it. Short-stem and stemless implants are designed to be convertible in that they can easily be removed in a timely manner. They give surgeons complete control over the first procedure, the aTSA, allowing for true anatomic reconstruction, and the second procedure, the rTSA, for executing a biomechanically sound reverse with optimal functional outcomes while minimizing potential complications associated with scapula notching.[38] Our response is built on our key aTSA and rTSA value propositions.

Arthrex doesn't offer patient-matched implants.

True. However, with solutions from "ream-and-run" hemiarthroplasty to bone grafting and the broadest glenoid baseplate augment system on the market, our off-the-shelf implants should accommodate the vast majority of pathology outside of something so drastic it needs a custom baseplate.

Negotiate

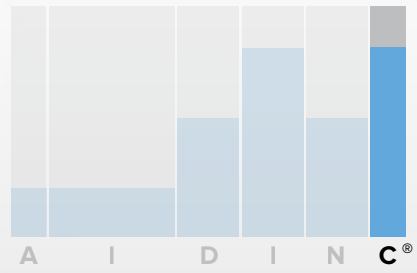
Nonclinical Objections

Arthrex implants cost more than others. / We want a single source for shoulder arthroplasty.
Pricing can always be addressed with support from your arthroplasty manager and business development manager. We have both peer-reviewed literature and patient-reported outcome measures (PROMs) to support the vast majority of our products. We also have value-adds like the VIP™ system and soft-tissue repair options (with peer-reviewed literature and PROMs) that most other shoulder arthroplasty companies cannot compete with. You're offering a system, not implants, and it should be presented that way.

Close

Action Guides™

- **Identify** incremental commitments that lead to a decision
- **Listen** to and reinforce each response
- **Be** aware of buying signals
- **Ask** for an appropriate closing commitment



For further information, see the **ECI Reference Guide**.

What to Expect

- Expect the arthroplasty sales cycle to be a more involved process, requiring multiple steps along the path to success. Keep in mind there should be one closing action in every interaction. Always lead with the next step.
- Focus on driving them toward a lab, demo, or a course that will continue the conversation as you build a long-term relationship.

Closing Opportunities

Invitation to:

- Demo
- Dry or wet lab
- Medical education course
- Trial a product
- Propose product to a value analysis committee
- Virtual Arthrex Experience
- SDL in Naples with the Arthrex Experience Team

Appendix

Sales Tools

Surgical Technique Guides

Eclipse™ Stemless Shoulder Arthroplasty System
LT1-000009-en-US

Univers™ II Total Shoulder System
LT1-0701-EN

Univers™ Apex Total Shoulder System
LT1-0702-EN

Universal Glenoid™ Convertible Baseplate
LT1-000000-en-US

Univers Revers™ Total Shoulder System
LT1-0703-EN

Univers Revers™ Shoulder System Humeral Preparation
LT1-000175-en-US

Univers Revers™ Modular Glenoid System
LT1-00112-EN

Univers Revers™ Modular Glenoid System
LT1-000169-en-US

Bone Graft Preparation for the Univers Revers™ Modular Glenoid System
LT1-000047-en-US

Virtual Implant Positioning™ (VIP) Glenoid Targeter
LT1-000040-en-US

Animations

Eclipse™ Total Shoulder Arthroplasty System
AN1-0116-EN

Univers™ II System & Univers Apex - Head and Proximal Stem Design Philosophy
AN1-00061-EN

Univers™ Apex Optimized Anatomic Arthroplasty
AN1-00265-EN

Univers VaultLock®
AN1-00241-EN

Univers Revers™ Universal Glenoid™ Convertible Baseplate
AN1-00305-EN

Universal Glenoid™ Convertible Baseplate Features and Benefits
AN1-000036-en-US

Univers Revers™ Total Shoulder Arthroplasty
AN1-00112-EN

Univers Revers™ Modular Glenoid System
AN1-000035-en-US

Univers Revers™ Augmented Modular Glenoid System: Full-Wedge Baseplate
AN1-000274-en-US

Virtual Implant Positioning™ (VIP) Transfer Instrumentation
AN1-00273-EN

Appendix

Sales Tools

Videos

Total Shoulder Replacement Using Eclipse™ Total Shoulder Arthroplasty System
VID1-000615-en-US
Anthony A. Romeo, MD (New York, NY)

Eclipse™ SpeedScap™ Implant System and Subscapularis Repair for aTSA
VID1-001836-en-US
Laurence D. Higgins, MD, MBA (Naples, FL)

Univers™ Apex - Cadaveric Demonstration
VID1-00135-EN

Univers VaultLock® Glenoid System
VID1-00941-EN
Patrick J. Denard, MD (Medford, OR)

Universal Glenoid™ Convertible Baseplate for aTSA in the Dysplastic Glenoid
VID1-002157-en-US
Tim R. Lenters, MD (Grand Rapids, MI)

Univers Revers™ Cadaveric Demonstration
VID1-00106-EN

Univers™ II Congruent Glenoid Reamer Set
VID1-00105-EN

Univers Revers™ Modular Glenoid System
VID1-000252-en-US
Justin W. Griffin, MD (Virginia Beach, VA)

Modular Glenoid System (MGS) Bone Graft Instrumentation
VID1-001874-en-US
Justin W. Griffin, MD (Virginia Beach, VA)

Univers Revers Augmented Modular Glenoid System Full-Wedge Baseplate
VID1-001370-en-US
Patrick J. Denard, MD (Medford, OR)

Appendix

Ordering Information

Instrument Sets

Product Description	Item Number
Univers Revers™ Modular Glenoid System	AR-**9615S**
Univers Revers Augmented MGS Instrument Set	AR-**9579S**
Univers VaultLock® and Keeled Instrument Set	AR-**9217VKS**
Augmented Univers VaultLock Instrument Set	AR-**9217AVS**
Augmented Univers VaultLock XL Instrument Set	AR-**9217AVXLS**
Univers Revers Glenoid Instrument Set (CUG)	AR-**9501GS**

Implant Sets

Product Description	Item Number
Univers Revers Augmented MGS	AR-**9579SI**
Augmented MGS 15°/35° Half-Wedge	RAR-**9579-1535SI**
Univers VaultLock and Keeled Implant Set	AR-**9217SI**
Augmented Univers VaultLock Implant Set	AR-**9217ASI**
Augmented Univers VaultLock XL Implant Set	AR-**9217AXLSI**
Univers Revers Glenoid Implant Set (CUG)	AR-**9501GSI**

Augmented Univers VaultLock Glenoids

Product Description	Item Number
Small, 15°, left	AR-**9107-01-15L**
Small, 15°, right	AR-**9107-01-15R**
Small, 25°, left	AR-**9107-01-25L**
Small, 25°, right	AR-**9107-01-25R**
Medium, 15°, left	AR-**9107-02-15L**
Medium, 15°, right	AR-**9107-02-15R**
Medium, 25°, left	AR-**9107-02-25L**
Medium, 25°, right	AR-**9107-02-25R**
Large, 15°, left	AR-**9107-03-15L**
Large, 15°, right	AR-**9107-03-15R**
Large, 25°, left	AR-**9107-03-25L**
Large, 25°, right	AR-**9107-03-25R**
Product Description	**Item Number**
Special Order	
X-large, 15°, right	AR-**9107-04-15R**
X-large, 15°, left	AR-**9107-04-15L**
X-large, 25°, right	AR-**9107-04-25R**
X-large, 25°, left	AR-**9107-04-25L**
Angled Reamer, x-large	AR-**9275-XL**

Universal Glenoid™ Convertible Baseplates/ Inlay Polyethylene/Glenospheres Implants

Product Description	Item Number
Porous-Coated Baseplate, small	AR-**9120-01PC**
Porous-Coated Baseplate, medium	AR-**9120-02PC**
Porous-Coated Baseplate, large	AR-**9120-03PC**
Inlay, small	AR-**9121-01**
Inlay, medium	AR-**9121-02**
Inlay, large	AR-**9121-03**
Inlay, small PLUS	AR-**9121-04**
Inlay, medium PLUS	AR-**9121-05**
Inlay, large PLUS	AR-**9121-06**
Peripheral Locking Screw, 4.5 mm × 24 mm	AR-**9145-24**
Peripheral Locking Screw, 4.5 mm × 30 mm	AR-**9145-30**
Peripheral Locking Screw, 4.5 mm × 36 mm	AR-**9145-36**
Peripheral Locking Screw, 4.5 mm × 42 mm	AR-**9145-42**
Peripheral Locking Screw, 4.5 mm × 48 mm	AR-**9145-48**
Central Screw, 6.5 mm × 15 mm	AR-**9165-15**
Central Screw, 6.5 mm × 20 mm	AR-**9165-20**
Central Screw, 6.5 mm × 25 mm	AR-**9165-25**
Peripheral Screw, nonlocking, 4.5 mm × 24 mm	AR-**9145-24NL**
Peripheral Screw, nonlocking, 4.5 mm × 30 mm	AR-**9145-30NL**
Peripheral Screw, nonlocking, 4.5 mm × 36 mm	AR-**9145-36NL**
Peripheral Screw, nonlocking, 4.5 mm × 42 mm	AR-**9145-42NL**
Peripheral Screw, nonlocking, 4.5 mm × 48 mm	AR-**9145-48NL**
Central Screw, nonlocking, 6.5 mm × 15 mm	AR-**9165-15NL**
Central Screw, nonlocking, 6.5 mm × 20 mm	AR-**9165-20NL**
Central Screw, nonlocking, 6.5 mm × 25 mm	AR-**9165-25NL**
Glenosphere, 36	AR-**9504S**
Glenosphere, 36 +2.5 mm inf	AR-**9504S-INF**
Glenosphere, 36 +4 mm lat	AR-**9504S-04**
Glenosphere, 39 mm	AR-**9504M**
Glenosphere, 39 +2.5 mm inf	AR-**9504S-02**
Glenosphere, 39 +4 mm lat	AR-**9504M-04**
Glenosphere, 42 mm	AR-**9504L**
Glenosphere, 42 +2.5 mm inf	AR-**9504M-02**
Glenosphere, 42 +4 mm lat	AR-**9504L-04**

Please note that not all products advertised in this playbook may be available in all countries. Please ask the Arthrex Customer Service or your local Arthrex Representative before ordering if the desired product is available for delivery.

Appendix

Ordering Information

Modular Glenoid System Implants - Glenoid Baseplates

Product Description	Item Number
24 mm Baseplate, monoblock screw	AR-**9560-24S**
24 mm Baseplate, monoblock post	AR-**9560-24P**
24 mm Baseplate, modular	AR-**9560-24**
24 mm +2 mm Lateralized Baseplate, modular	AR-**9560-24-2**
24 mm +4 mm Lateralized Baseplate, modular	AR-**9560-24-4**
28 mm Baseplate, monoblock screw	AR-**9560-28S**
28 mm Baseplate, monoblock post	AR-**9560-28P**
28 mm Baseplate, modular	AR-**9560-28**
28 mm +2 mm Lateralized Baseplate, modular	AR-**9560-28-2**
28 mm +4 mm Lateralized Baseplate, modular	AR-**9560-28-4**

Modular Glenoid System Implants - Modular Central Fixation

Product Description	Item Number
20 mm Modular Central Screw	AR-**9561-20S**
25 mm Modular Central Screw	AR-**9561-25S**
30 mm Modular Central Screw	AR-**9561-30S**
35 mm Modular Central Screw	AR-**9561-35S**
20 mm Modular Central Post	AR-**9561-20P**
25 mm Modular Central Post	AR-**9561-25P**
30 mm Modular Central Post	AR-**9561-30P**
35 mm Modular Central Post	AR-**9561-35P**

Modular Glenoid System Implants - Peripheral Bone Screws

Product Description	Item Number
4.5 mm × 16 mm Screw, nonlocking	AR-**9562-16NL**
4.5 mm × 20 mm Screw, nonlocking	AR-**9562-20NL**
4.5 mm × 24 mm Screw, nonlocking	AR-**9562-24NL**
4.5 mm × 28 mm Screw, nonlocking	AR-**9562-28NL**
4.5 mm × 32 mm Screw, nonlocking	AR-**9562-32NL**
4.5 mm × 36 mm Screw, nonlocking	AR-**9562-36NL**
4.5 mm × 40 mm Screw, nonlocking	AR-**9562-40NL**
4.5 mm × 44 mm Screw, nonlocking	AR-**9562-44NL**
4.5 mm × 48 mm Screw, nonlocking	AR-**9562-48NL**
5.5 mm × 16 mm Screw, locking	AR-**9563-16**
5.5 mm × 20 mm Screw, locking	AR-**9563-20**
5.5 mm × 24 mm Screw, locking	AR-**9563-24**
5.5 mm × 28 mm Screw, locking	AR-**9563-28**
5.5 mm × 32 mm Screw, locking	AR-**9563-32**
5.5 mm × 36 mm Screw, locking	AR-**9563-36**
5.5 mm × 40 mm Screw, locking	AR-**9563-40**
5.5 mm × 44 mm Screw, locking	AR-**9563-44**
5.5 mm × 48 mm Screw, locking	AR-**9563-48**

Modular Glenoid System Implants - Glenospheres

Product Description	Item Number
33 mm Glenosphere, 24 mm baseplate taper	AR-**9564-2433**
33 mm +4 mm Lateralized Glenosphere, 24 mm baseplate taper	AR-**9564-2433-LAT**
36 mm Glenosphere, 24 baseplate taper	AR-**9564-2436**
36 mm +4 mm Lateralized Glenosphere, 24 mm baseplate taper	AR-**9564-2436-LAT**
36 mm +2.5 mm Eccentric Glenosphere, 24 mm baseplate taper	AR-**9564-2436-INF**
39 mm Glenosphere, 24 mm baseplate taper	AR-**9564-2439**
39 mm +4 mm Lateralized Glenosphere, 24 mm baseplate taper	AR-**9564-2439-LAT**
39 mm +2.5 mm Eccentric Glenosphere, 24 mm baseplate taper	AR-**9564-2439-INF**
42 mm Glenosphere, 24 mm baseplate taper	AR-**9564-2442**
42 mm +4 mm Lateralized Glenosphere, 24 mm baseplate taper	AR-**9564-2442-LAT**
42 mm + 2.5 mm Eccentric Glenosphere, 24 mm baseplate taper	AR-**9564-2442-INF**
45 mm/24 mm Glenosphere	AR-**9564-2445**
45 mm +2.5 mm Inf/24 mm Glenosphere	AR-**9564-2445-INF**
45 mm +4 mm Lat/24 mm Glenosphere	AR-**9564-2445-LAT**
36 mm Glenosphere, 28 mm baseplate taper	AR-**9564-2836**
36 mm +4 mm Lateralized Glenosphere, 28 mm baseplate taper	AR-**9564-2836-LAT**
39 mm Glenosphere, 28 mm baseplate taper	AR-**9564-2839**
39 mm +4 mm Lateralized Glenosphere, 28 mm baseplate taper	AR-**9564-2839-LAT**
39 mm +2.5 mm Eccentric Glenosphere, 28 mm baseplate taper	AR-**9564-2839-INF**
42 mm Glenosphere, 28 mm baseplate taper	AR-**9564-2842**
42 mm +4 mm Lateralized Glenosphere, 28 mm baseplate taper	AR-**9564-2842-LAT**
42 mm +2.5 mm Eccentric Glenosphere, 28 mm baseplate taper	AR-**9564-2842-INF**
45 mm/28 mm Glenosphere	AR-**9564-2845**
45 mm +2.5 mm Inf/28 mm Glenosphere	AR-**9564-2845-INF**
45 mm +4 mm Lat/28 mm Glenosphere	AR-**9564-2845-LAT**

Please note that not all products advertised in this playbook may be available in all countries. Please ask the Arthrex Customer Service or your local Arthrex Representative before ordering if the desired product is available for delivery.

Appendix

Ordering Information

Augmented Modular Glenoid System Full-Wedge Implants

Product Description	Item Number
24 mm Baseplate, 10° full augment, oblique	AR-**9580-2410**
24 mm Baseplate, 20° full augment, oblique	AR-**9580-2420**
24 mm Baseplate, 10° full augment, +2 mm lateralized, oblique	AR-**9580-2410-2**
24 mm Baseplate, 20° full augment, +2 mm lateralized, oblique	AR-**9580-2420-2**
24 mm Baseplate, 10° full augment	AR-**9580-2410S**
24 mm Baseplate, 20° full augment	AR-**9580-2420S**
24 mm Baseplate, 10° full augment, +2 mm lateralized	AR-**9580-2410-2S**
24 mm Baseplate, 20° full augment, +2 mm lateralized	AR-**9580-2420-2S**

Augmented Modular Glenoid System Half-Wedge Implants

Product Description	Item Number
24 mm Baseplate, 15° half augment, oblique	AR-**9581-2415**
24 mm Baseplate, 25° half augment, oblique	AR-**9581-2425**
24 mm Baseplate, 35° half augment, oblique	AR-**9581-2435**
24 mm Baseplate, 15° half augment, +2 mm lateralized, oblique	AR-**9581-2415-2**
24 mm Baseplate, 25° half augment, +2 mm lateralized, oblique	AR-**9581-2425-2**
24 mm Baseplate, 35° half augment, +2 mm lateralized, oblique	AR-**9581-2435-2**
24 mm Baseplate, 15° half augment	AR-**9581-2415S**
24 mm Baseplate, 25° half augment	AR-**9581-2425S**
24 mm Baseplate, 35° half augment	AR-**9581-2435S**
24 mm Baseplate, 15° half augment, +2 mm lateralized	AR-**9581-2415-2S**
24 mm Baseplate, 25° half augment, +2 mm lateralized	AR-**9581-2425-2S**
24 mm Baseplate, 35° half augment, +2 mm lateralized	AR-**9581-2435-2S**

Modular Posts

Product Description	Item Number
Modular Post, 20 mm	AR-**9582-20**
Modular Post, 25 mm	AR-**9582-25**
Modular Post, 30 mm	AR-**9582-30**
Modular Post, 35 mm	AR-**9582-35**
Modular Post, 40 mm	AR-**9582-40**

Disposables

Product Description	Item Number
Angled Reamer, small	AR-**9675-S**
Angled Reamer, medium	AR-**9675-M**
Angled Reamer, large	AR-**9675-L**
Angled Reamer, X-large	AR-**9675-XL**
3.0 mm Drill	AR-**9628S**

Additional Instrument Sets

Product Description	Item Number
Congruent Reamer Set	AR-**9200-RRS**
Univers Revers™ Bone Graft Instrument Set	AR-**9665-S**

Please note that not all products advertised in this playbook may be available in all countries. Please ask the Arthrex Customer Service or your local Arthrex Representative before ordering if the desired product is available for delivery.

Appendix

References

1. Bryce CD, Davison AC, Lewis GS, Wang L, Flemming DJ, Armstrong AD. Two-dimensional glenoid version measurements vary with coronal and sagittal scapular rotation. *J Bone Joint Surg Am*. 2010;92(3):692-699. doi:10.2106/JBJS.I.00177

2. Budge MD, Lewis GS, Schaefer E, Coquia S, Flemming DJ, Armstrong AD. Comparison of standard two-dimensional and three-dimensional corrected glenoid version measurements. *J Shoulder Elbow Surg*. 2011;20(4):577-583. doi:10.1016/j.jse.2010.11.003

3. Chalmers PN, Salazar D, Chamberlain A, Keener JD. Radiographic characterization of the B2 glenoid: the effect of computed tomographic axis orientation. *J Shoulder Elbow Surg*. 2017;26(2):258-264. doi:10.1016/j.jse.2016.07.021

4. Hoenecke HR Jr, Hermida JC, Flores-Hernandez C, D'Lima DD. Accuracy of CT-based measurements of glenoid version for total shoulder arthroplasty. *J Shoulder Elbow Surg*. 2010;19(2):166-171. doi:10.1016/j.jse.2009.08.009

5. Heylen S, Van Haver A, Vuylsteke K, Declercq G, Verborgt O. Patient-specific instrument guidance of glenoid component implantation reduces inclination variability in total and reverse shoulder arthroplasty. *J Shoulder Elbow Surg*. 2016;25(2):186-192. doi:10.1016/j.jse.2015.07.024

6. Scalise JJ, Codsi MJ, Bryan J, Brems JJ, Iannotti JP. The influence of three-dimensional computed tomography images of the shoulder in preoperative planning for total shoulder arthroplasty. *J Bone Joint Surg Am*. 2008;90(11):2438-2445. doi:10.2106/JBJS.G.01341

7. Werner BS, Hudek R, Burkhart KJ, Gohlke F. The influence of three-dimensional planning on decision-making in total shoulder arthroplasty. *J Shoulder Elbow Surg*. 2017;26(8):1477-1483. doi:10.1016/j.jse.2017.01.006

8. Cancienne JM, Dempsey IJ, Garrigues GE, Cole BJ, Brockmeier SF, Werner BC. Trends and impact of three-dimensional preoperative imaging for anatomic total shoulder arthroplasty [published online March 2, 2020]. *Shoulder Elbow*. 2020. doi:10.1177/1758573220908865

9. Rouleau DM, Kidder JF, Pons-Villanueva J, Dynamidis S, Defranco M, Walch G. Glenoid version: how to measure it? Validity of different methods in two-dimensional computed tomography scans. *J Shoulder Elbow Surg*. 2010;19(8):1230-1237. doi:10.1016/j.jse.2010.01.027

10. Walch G, Young AA, Boileau P, Loew M, Gazielly D, Molé D. Patterns of loosening of polyethylene keeled glenoid components after shoulder arthroplasty for primary osteoarthritis: results of a multicenter study with more than five years of follow-up. *J Bone Joint Surg Am*. 2012;94(2):145-150. doi:10.2106/JBJS.J.00699

11. Ho JC, Sabesan VJ, Iannotti JP. Glenoid component retroversion is associated with osteolysis. *J Bone Joint Surg Am*. 2013;95(12):e82. doi:10.2106/JBJS.L.00336

12. Dilisio MF, May NR, Vincent SA, et al. The association of incomplete glenoid component seating and periprosthetic glenoid radiolucencies after total shoulder arthroplasty. *J Shoulder Elbow Surg*. 2016;25(3):442-447. doi:10.1016/j.jse.2015.08.005

13. Keener JD, Patterson BM, Orvets N, Aleem AW, Chamberlain AM. Optimizing reverse shoulder arthroplasty component position in the setting of advanced arthritis with posterior glenoid erosion: a computer-enhanced range of motion analysis. *J Shoulder Elbow Surg*. 2018;27(2):339-349. doi:10.1016/j.jse.2017.09.011

14. Boileau P, Gauci MO, Wagner ER, et al. The reverse shoulder arthroplasty angle: a new measurement of glenoid inclination for reverse shoulder arthroplasty. *J Shoulder Elbow Surg*. 2019;28(7):1281-1290. doi:10.1016/j.jse.2018.11.074

15. Wong AS, Gallo L, Kuhn JE, Carpenter JE, Hughes RE. The effect of glenoid inclination on superior humeral head migration. *J Shoulder Elbow Surg*. 2003;12(4):360-364. doi:10.1016/s1058-2746(03)00026-0

16. Oosterom R, Rozing PM, Bersee HE. Effect of glenoid component inclination on its fixation and humeral head subluxation in total shoulder arthroplasty. *Clin Biomech (Bristol, Avon)*. 2004;19(10):1000-1008. doi:10.1016/j.clinbiomech.2004.07.001

17. Li X, Knutson Z, Choi D, et al. Effects of glenosphere positioning on impingement-free internal and external rotation after reverse total shoulder arthroplasty. *J*

Appendix

References

Shoulder Elbow Surg. 2013;22(6):807-813. doi:10.1016/j.jse.2012.07.013

18. Tashjian RZ, Martin BI, Ricketts CA, Henninger HB, Granger EK, Chalmers PN. Superior Baseplate Inclination Is Associated With Instability After Reverse Total Shoulder Arthroplasty. *Clin Orthop Relat Res*. 2018;476(8):1622-1629. doi:10.1097/CORR.0000000000000340

19. Gobezie R, Shishani Y, Lederman E, Denard PJ. Can a functional difference be detected in reverse arthroplasty with 135° versus 155° prosthesis for the treatment of rotator cuff arthropathy: a prospective randomized study. *J Shoulder Elbow Surg*. 2019;28(5):813-818. doi:10.1016/j.jse.2018.11.064

20. Gutiérrez S, Walker M, Willis M, Pupello DR, Frankle MA. Effects of tilt and glenosphere eccentricity on baseplate/bone interface forces in a computational model, validated by a mechanical model, of reverse shoulder arthroplasty. *J Shoulder Elbow Surg*. 2011;20(5):732-739. doi:10.1016/j.jse.2010.10.035

21. Verhaegen F, Campopiano E, Debeer P, Scheys L, Innocenti B. How much bone support does an anatomic glenoid component need?. *J Shoulder Elbow Surg*. 2020;29(4):743-754. doi:10.1016/j.jse.2019.09.019

22. Formaini NT, Everding NG, Levy JC, et al. The effect of glenoid bone loss on reverse shoulder arthroplasty baseplate fixation. *J Shoulder Elbow Surg*. 2015;24(11):e312-e319. doi:10.1016/j.jse.2015.05.045

23. Martin EJ, Duquin TR, Ehrensberger MT. Reverse total shoulder glenoid baseplate stability with superior glenoid bone loss. *J Shoulder Elbow Surg*. 2017;26(10):1748-1755. doi:10.1016/j.jse.2017.04.020

24. Vance DD, O'Donnell JA, Baldwin EL 3rd, et al. Risk of suprascapular nerve injury during glenoid baseplate fixation for reverse total shoulder arthroplasty; a cadaveric study [published online July 21, 2020]. *J Shoulder Elbow Surg*. 2020;S1058-2746(20)30572-3. doi:10.1016/j.jse.2020.07.008

25. Crosby LA, Hamilton A, Twiss T. Scapula fractures after reverse total shoulder arthroplasty: classification and treatment. *Clin Orthop Relat Res*. 2011;469(9):2544-2549. doi:10.1007/s11999-011-1881-3

26. Kennon JC, Lu C, McGee-Lawrence ME, Crosby LA. Scapula fracture incidence in reverse total shoulder arthroplasty using screws above or below metaglene central cage: clinical and biomechanical outcomes. *J Shoulder Elbow Surg*. 2017;26(6):1023-1030. doi:10.1016/j.jse.2016.10.018

27. Erickson BJ, Chalmers PN, Denard P, et al. Does commercially available shoulder arthroplasty preoperative planning software agree with surgeon measurements of version, inclination, and subluxation [published online June 13, 2020]? *J Shoulder Elbow Surg*. 2020;S1058-2746(20)30473-0. doi:10.1016/j.jse.2020.05.027

28. Dillon MT, Chan PH, Prentice HA, Burfeind WE, Yian EH, Singh A, Paxton EW, Navarro RA. The association between glenoid component design and revision risk in anatomic total shoulder arthroplasty. *J Shoulder Elbow Surg*. 2020;29(10):2089-2096. doi: 10.1016/j.jse.2020.02.024

29. Magosch P, Lichtenberg S, Tauber M, Martetschläger F, Habermeyer P. Prospective midterm results of a new convertible glenoid component in anatomic shoulder arthroplasty: a cohort study. *Arch Orthop Trauma Surg*. 2021 May;141(5):717-724. doi:10.1007/s00402-020-03454-y

30. Werner BS, Chaoui J, Walch G. The influence of humeral neck shaft angle and glenoid lateralization on range of motion in reverse shoulder arthroplasty. *J Shoulder Elbow Surg*. 2017;26(10):1726-1731. doi:10.1016/j.jse.2017.03.032.

31. Day JS, MacDonald DW, Olsen M, Getz C, Williams GR, Kurtz SM. Polyethylene wear in retrieved reverse total shoulder components. *J Shoulder Elbow Surg*. 2012;21(5):667-74. doi:10.1016/j.jse.2011.03.012.

32. Lewicki KA, Bell JE, Van Citters DW. Analysis of polyethylene wear of reverse shoulder components: A validated technique and initial clinical results. *J Orthop Res*. 2017;35(5):980-987. doi:10.1002/jor.23353

33. Formaini NT, Everding NG, Levy JC, et al. The effect of glenoid bone loss on reverse shoulder arthroplasty baseplate fixation. *J Shoulder Elbow Surg*. 2015;24(11):e312-e319. doi:10.1016/j.jse.2015.05.045

Appendix

References

34. Gulotta LV, Chambers KL, Warren RF, Dines DM, Craig EV. No differences in early results of a hybrid glenoid compared with a pegged implant. *Clin Orthop Relat Res*. 2015;473(12):3918-24. doi:10.1007/s11999-015-4558-5

35. Churchill RS, Chuinard C, Water JM, et al. Clinical and radiographic outcomes of the Simpliciti canal-sparing shoulder arthroplasty system: a prospective two-year multicenter study. *J Bone Joint Surg Am*. 2016;98(7):552-560. doi:10.2106/JBJS.15.00181

36. Kadum B, Mukka S, Englund E, Sayed-Noor A, Sjödén G. Clinical and radiological outcome of the Total Evolutive Shoulder System (TESS®) reverse shoulder arthroplasty: a prospective comparative non-randomised study. *Int Orthop*. 2014;38(5):1001-1006. doi:10.1007/s00264-013-2277-7

37. Anthony CA, Westermann RW, Gao Y, Pugely AJ, Wolf BR, Hettrich CM. What are risk factors for 30-day morbidity and transfusion in total shoulder arthroplasty? A review of 1922 cases. *Clin Orthop Relat Res*. 2015:473(6):2099-2105. doi:10.1007/s11999-014-4107-7

38. Walch G. What I've learned? *J Shoulder Elbow Sur*g. 2019;28(6):1214-1216. doi:10.1016/j.jse.2019.02.018

arthrex.com