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Reverse Shoulder Arthroplasty with Virtual Implant Positioning System in the Management of Massive Rotator Cuff Tear with Rotator Cuff Arthropathy

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Learning Point of the Article:

Computed tomography-based virtual implant positioning enhances the precision of reverse shoulder arthroplasty, facilitating accurate implant placement, stable fixation, and excellent functional recovery in rotator cuff arthropathy.

Abstract

Introduction: Massive irreparable rotator cuff tears associated with cuff tear arthropathy present a challenging clinical condition in elderly patients because of pain, loss of shoulder function, and progressive degenerative changes. Reverse shoulder arthroplasty (RSA) has emerged as the preferred surgical treatment by restoring shoulder biomechanics through medialization and inferiorization of the glenohumeral center of rotation. Recent advances, including computed tomography (CT)-based virtual implant positioning (VIP) systems, have further improved implant positioning accuracy and surgical planning.

Case Report: A 78-year-old right-hand-dominant female presented with progressive pain and functional limitation of the right shoulder following a slip-and-fall injury 1 month earlier. Clinical examination demonstrated painful restriction of shoulder movements with positive rotator cuff tests. Radiographs revealed acromioclavicular joint arthritis, whereas magnetic resonance imaging demonstrated full-thickness tears of the supraspinatus and infraspinatus tendons, a partial tear of the subscapularis tendon, Grade IV muscle atrophy, and rotator cuff arthropathy with moderate glenohumeral osteoarthritis. The patient underwent RSA using a CT-based VIP system. Glenoid preparation, baseplate fixation, glenosphere implantation, and humeral component placement were performed according to the pre-operative surgical plan, followed by a structured post-operative rehabilitation protocol. At the 10-month follow-up, the patient experienced complete pain relief, restoration of functional shoulder movements, and a successful return to activities of daily living without complications.

Conclusion: RSA combined with VIP provided accurate implant placement, stable fixation, excellent functional recovery, and satisfactory clinical outcome in this patient with rotator cuff arthropathy.

Keywords: Reverse shoulder arthroplasty, rotator cuff arthropathy, virtual implant positioning, massive rotator cuff tear, shoulder reconstruction.

Introduction

Massive rotator cuff tears represent one of the most debilitating disorders affecting the elderly population. They are frequently associated with progressive pain, shoulder weakness, pseudoparalysis, and deterioration of quality of life. These tears usually involve complete disruption of two or more rotator cuff tendons and often become irreparable because of tendon retraction, fatty infiltration, muscle atrophy, and chronic degeneration. Continued superior migration of the humeral head eventually results in cuff tear arthropathy, characterized by

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Author's Photo Gallery

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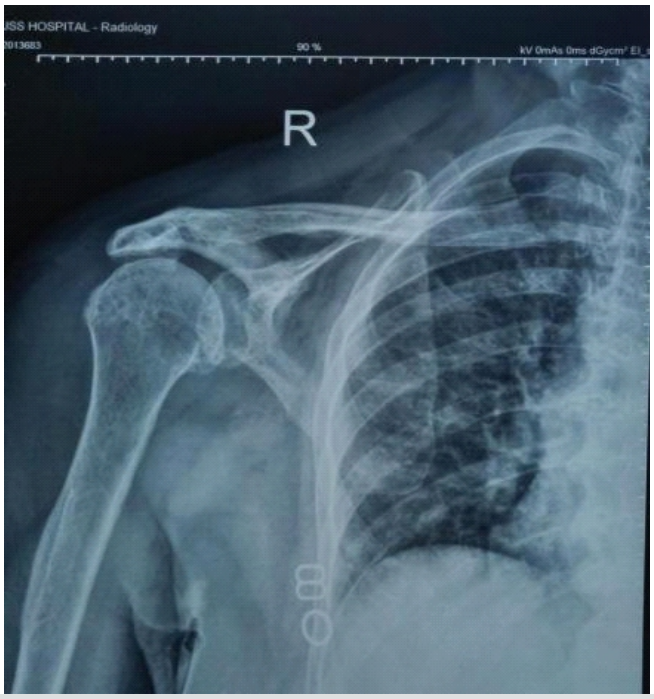

Figure 1: Pre-operative and post-operative radiographs of the right shoulder. (a) Pre-operative radiograph showing degenerative changes consistent with rotator cuff arthropathy.

degenerative destruction of the glenohumeral joint, acetabularization of the acromion, narrowing of the acromiohumeral interval, and progressive loss of shoulder function. Conventional treatment options, including physiotherapy, analgesics, corticosteroid injections, arthroscopic debridement, tendon transfers, and hemiarthroplasty, frequently provide only temporary symptomatic relief in patients with advanced cuff tear arthropathy and are associated with unsatisfactory long-term functional outcomes [1].

The development of reverse shoulder arthroplasty (RSA) has revolutionized the treatment of irreparable rotator cuff deficiency. Initially conceptualized by Grammont et al., RSA differs fundamentally from conventional shoulder arthroplasty by reversing the normal ball-and-socket anatomy of the glenohumeral joint. In this design, a convex glenosphere is implanted on the glenoid side while a concave polyethylene cup is fixed to the humeral component. This biomechanical alteration medializes and inferiorizes the center of rotation, thereby increasing the deltoid muscle lever arm and allowing the deltoid to compensate for the deficient rotator cuff. Consequently, patients regain active shoulder elevation despite the absence of functional rotator cuff tendons [2].

During the past two decades, indications for RSA have expanded considerably. Besides cuff tear arthropathy, RSA is currently utilized in proximal humeral fractures in elderly patients, revision shoulder arthroplasty, failed hemiarthroplasty, inflammatory arthritis, post-traumatic arthritis, chronic glenohumeral dislocations, tumor reconstruction, and severe glenoid bone loss. Numerous clinical studies have demonstrated substantial improvements in pain relief, shoulder function, range of motion, and patient satisfaction following RSA. Functional outcomes have been particularly encouraging in elderly low-demand individuals with irreparable cuff pathology [3].

Despite these encouraging results, accurate implant positioning remains one of the most critical determinants of successful RSA. Malposition of the glenoid baseplate may predispose to instability, scapular notching, component loosening, polyethylene wear, screw failure, and early revision surgery. Precise glenoid inclination, version correction, screw orientation, and baseplate fixation are therefore essential to maximize implant longevity and optimize shoulder biomechanics [4].

Recent technological advances have introduced computer-assisted planning systems into shoulder arthroplasty. Among these, the virtual implant positioning (VIP) system utilizes three-dimensional computed tomography (CT) reconstruction to allow detailed pre-operative assessment of glenoid morphology, bone stock, implant sizing, baseplate

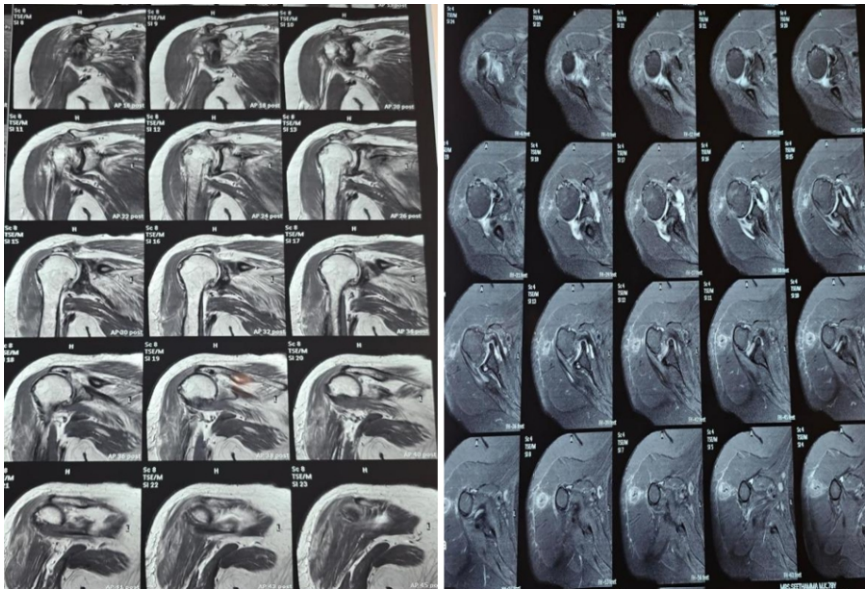

Figure 2: Pre-operative magnetic resonance imaging of the right shoulder demonstrating massive rotator cuff pathology with full-thickness supraspinatus and infraspinatus tears, advanced fatty muscle atrophy, partial subscapularis tear, and associated glenohumeral degenerative changes.

Figure 3: Pre-operative clinical preparation and positioning of the right shoulder before reverse shoulder arthroplasty.

placement, screw trajectory, and glenosphere orientation before surgery. Such individualized planning facilitates accurate execution of the surgical procedure while minimizing intraoperative uncertainty. Several studies have demonstrated that CT-based planning significantly improves implant positioning accuracy and reduces technical errors compared with conventional techniques [5].

Virtual planning is particularly advantageous in patients with distorted anatomy, glenoid erosion, severe osteoarthritis, or bone deficiency, where conventional intraoperative estimation may be unreliable. By enabling precise implant placement, VIP technology contributes to improved primary fixation, enhanced stability, reduced complication rates, and potentially better long-term survivorship of RSA implants [6]. This report highlights the clinical presentation, radiological findings, surgical technique, post-operative rehabilitation, and functional outcome while emphasizing the advantages of CT-based virtual planning in achieving accurate implant positioning and excellent post-operative recovery in complex shoulder reconstruction.

Case Report

A 78-year-old right-hand dominant female presented with persistent right shoulder pain and progressive difficulty performing overhead activities 1 month after a slip-and-fall injury. The pain gradually worsened despite analgesics and rest, affecting activities of daily living such as dressing, combing her hair, lifting objects, and sleeping on the affected side. There was no history of previous shoulder surgery, infection, inflammatory arthritis, or neurological deficit.

Clinical examination

Examination revealed tenderness over the anterior glenohumeral joint and greater and lesser tuberosities. Active shoulder movements, particularly forward flexion, abduction, and external rotation, were markedly painful and restricted, while passive movements were relatively preserved. Rotator cuff tests were positive with reduced muscle strength, and the distal neurovascular examination was normal.

Radiological findings

Plain radiographs showed acromioclavicular joint arthritis (Fig. 1) and degenerative glenohumeral changes suggestive of rotator cuff arthropathy. Magnetic resonance imaging (MRI) confirmed full-thickness tears of the supraspinatus and infraspinatus with Grade IV fatty atrophy, a partial subscapularis tear, and moderate glenohumeral osteoarthritis (Fig. 2), establishing the diagnosis of irreparable rotator cuff tear arthropathy.

Pre-operative planning

Considering the patient's age, advanced cuff tear arthropathy, severe muscle atrophy, and functional limitation, RSA was planned. CT-based VIP was used for three-dimensional assessment of glenoid anatomy, implant sizing, baseplate positioning, and screw trajectory to optimize implant placement.

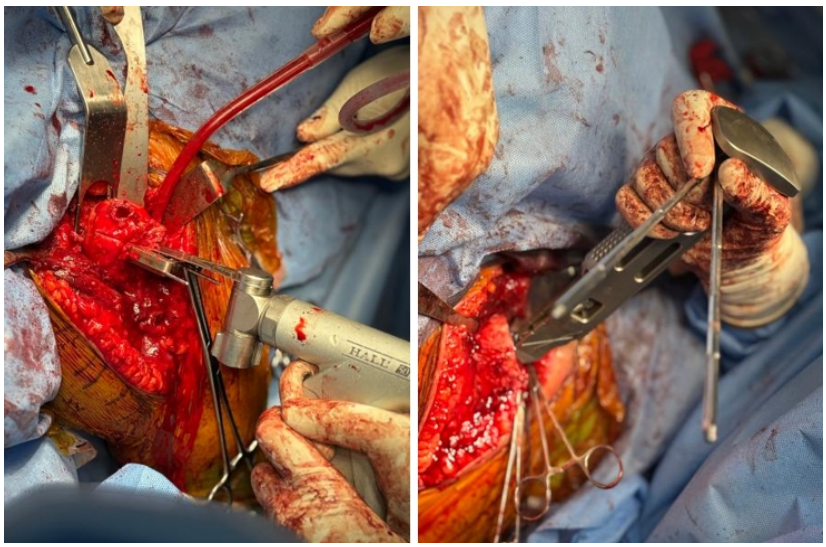

Figure 4: Intraoperative steps during reverse shoulder arthroplasty through the deltopectoral approach, demonstrating exposure and preparation of the proximal humerus and glenoid.

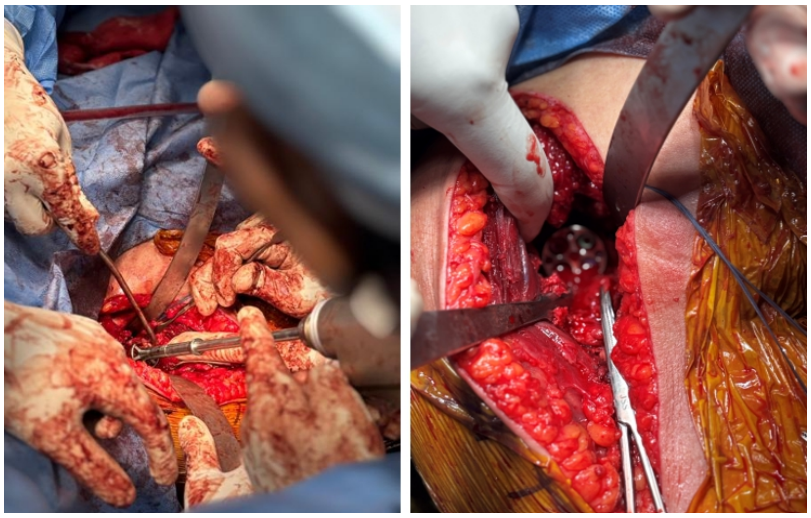

Figure 5: Intraoperative continuation of reverse shoulder arthroplasty demonstrating glenoid preparation and implantation of the glenoid-sided components.

Surgical procedure

RSA was performed under general anesthesia with a regional block using a standard deltopectoral approach (Fig. 3). After humeral head resection and preparation of the humerus and glenoid, the baseplate, glenosphere, humeral stem, and polyethylene insert were implanted according to the VIP plan (Fig. 4,5,6). The shoulder was reduced with satisfactory stability and range of motion, and the wound was closed without complications (Fig. 7).

Post-operative rehabilitation

A structured rehabilitation protocol was followed, beginning with protected passive shoulder mobilization during the first 3 weeks, followed by active-assisted range-of-motion exercises between weeks 4 and 6. Strengthening of the deltoid and scapular stabilizers was initiated after 6 weeks, with progressive resistance and functional rehabilitation continued until 16 weeks (Fig. 8).

Outcome

The post-operative course was uneventful. At the 10-month follow-up, the patient was pain-free with significant improvement in shoulder motion and function, allowing independent performance of daily activities. Follow-up radiographs demonstrated stable implant fixation without loosening, scapular notching, or component migration.

Discussion

RSA has become the standard surgical treatment for elderly patients with massive irreparable rotator cuff tears associated with cuff tear arthropathy. Unlike conventional shoulder arthroplasty, RSA restores shoulder function by medializing and distalizing the glenohumeral center of rotation, thereby increasing the mechanical advantage of the deltoid muscle and compensating for deficient rotator cuff muscles. In the present case, a 78-year-old female with a massive rotator cuff tear, Grade IV muscle atrophy, and cuff tear arthropathy underwent RSA with CT-based VIP. At the 10-month follow-up, the patient achieved complete pain relief, restoration of functional shoulder movements, and return to independent daily activities without complications, demonstrating the effectiveness of modern RSA combined with advanced pre-operative planning.

The findings of our case are consistent with the landmark multicenter study by Sirveaux et al. [7], which evaluated 80 shoulders with cuff tear arthropathy treated using the Grammont reverse prosthesis. They reported significant improvement in shoulder function, pain reduction, and active forward elevation, concluding that RSA is an effective treatment for patients with irreparable rotator cuff tears and glenohumeral arthritis. Similar to their findings, our patient experienced excellent pain relief and regained satisfactory shoulder function after RSA.

Figure 6: Intraoperative view demonstrating the implanted glenoid component/baseplate during reverse shoulder arthroplasty.

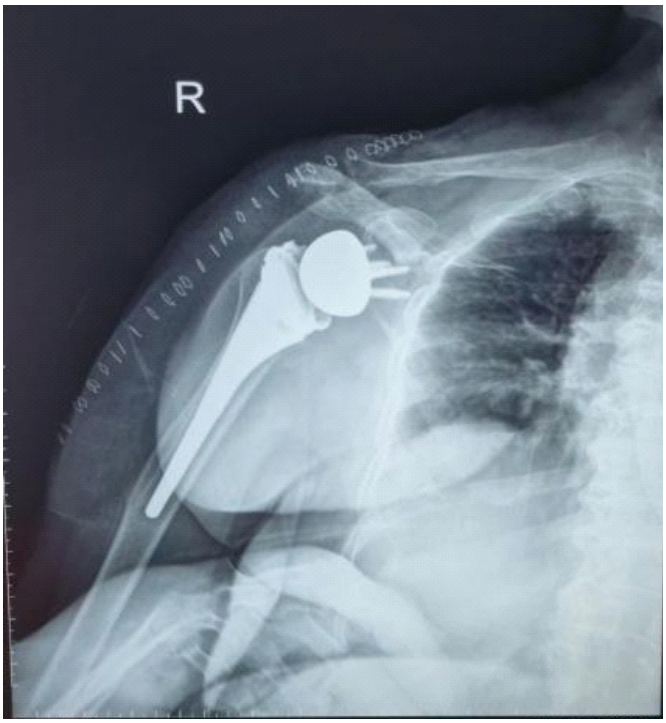

Figure 7: post-operative radiograph following reverse shoulder arthroplasty showing the prosthetic components in position.

Our results also correlate well with the study by Frankle et al. [8], which evaluated 60 patients with glenohumeral arthritis associated with severe rotator cuff deficiency. They demonstrated marked improvements in pain scores, shoulder elevation, and patient satisfaction after RSA, with low complication rates during a minimum 2-year follow-up. Likewise, our patient showed complete pain relief and excellent functional recovery without post-operative instability or prosthetic complications.

Figure 8: Clinical photographs at follow-up demonstrating restoration of active overhead elevation and functional range of motion of the operated right shoulder.

Another important comparison can be made with the Neer Award-winning study by Boileau et al. [9], which assessed the clinical performance of the Grammont reverse shoulder prosthesis in patients with cuff tear arthropathy, fracture sequelae, and failed shoulder arthroplasty. The authors concluded that RSA consistently improved shoulder function and relieved pain, although they emphasized that precise component positioning was essential to avoid complications such as instability and scapular notching. Our case supports these observations because CT-based VIP enabled accurate glenoid baseplate placement and optimal screw orientation, resulting in excellent implant stability and an uncomplicated post-operative course.

The long-term durability of RSA has been demonstrated by Guery et al. [10], who reported survivorship analysis of RSA with follow-up extending up to 10 years. They observed high implant survival and sustained clinical improvement, confirming RSA as a reliable long-term solution for cuff tear arthropathy. Although our follow-up period was limited to 10 months, the patient demonstrated stable radiographic fixation, excellent clinical improvement, and no evidence of implant loosening or instability, suggesting a favorable long-term prognosis.

Our case also agrees with the systematic review conducted by Wall et al. [11], which analyzed outcomes of RSA across various clinical indications. They reported that patients with cuff tear arthropathy achieved the most predictable improvements in pain relief, shoulder elevation, and overall functional outcomes compared with other indications for RSA. Similarly, our patient belonged to this ideal indication group and demonstrated remarkable functional recovery following surgery.

An important aspect of the present case was the utilization of CT-based VIP. Modern literature increasingly supports computer-assisted pre-operative planning to improve surgical precision. Recent work on three-dimensional pre-operative planning systems has demonstrated that virtual planning improves implant positioning, optimizes glenoid component orientation, and facilitates accurate screw trajectory selection, thereby minimizing complications related to malpositioning. The successful outcome observed in our patient further supports the growing evidence favoring CT-based planning in complex shoulder arthroplasty.

The biomechanical rationale underlying RSA has

been comprehensively explained by Boileau et al. [2], who described how medialization and distalization of the center of rotation enhance deltoid efficiency and restore active shoulder elevation despite complete rotator cuff deficiency. The excellent post-operative function achieved in our patient directly reflects these biomechanical principles, as active shoulder movement was restored despite MRI evidence of full-thickness supraspinatus and infraspinatus tears with advanced muscle atrophy.

Recent implant innovations have also focused on reducing complications associated with the original Grammont design. The successful outcome in our patient can be attributed to several factors. First, appropriate patient selection was performed, as the patient presented with classic indications for RSA, including advanced cuff tear arthropathy, irreparable tendon tears, and severe fatty degeneration. Second, CT-based VIP enabled individualized surgical planning, improving the accuracy of glenoid preparation and baseplate fixation. Third, meticulous surgical technique using the deltopectoral approach ensured adequate exposure and stable prosthetic implantation. Finally, adherence to a structured rehabilitation protocol facilitated the gradual restoration of shoulder mobility and muscle strength while minimizing the risk of instability or implant-related complications. The present case reinforces the growing body of evidence demonstrating that RSA is an effective treatment for massive irreparable rotator cuff tears with cuff tear arthropathy. Furthermore, incorporation of CT-based VIP may enhance surgical precision, improve implant stability, and contribute to excellent clinical and functional outcomes in carefully selected patients.

Conclusion

RSA with CT-based VIP proved to be an effective surgical option for the management of a massive irreparable rotator cuff tear associated with rotator cuff arthropathy in this elderly patient. The procedure successfully restored shoulder biomechanics, provided excellent pain relief, and resulted in substantial improvement in functional range of motion and activities of daily living. Pre-operative three-dimensional virtual planning facilitated accurate glenoid component positioning, optimal screw placement, and stable implant fixation, thereby minimizing the risk of implant-related complications. The patient's uneventful post-operative recovery and excellent clinical outcome at the 10-month follow-up are consistent with findings reported in the current literature supporting RSA as the treatment of choice for cuff tear arthropathy. This case further highlights the clinical value of integrating advanced CT-based virtual planning with meticulous surgical technique and structured rehabilitation to achieve predictable functional outcomes. Although long-term follow-up and larger clinical studies are needed to establish the sustained benefits of VIP, this report demonstrates that RSA combined with modern pre-operative planning technology is a safe, reliable, and effective treatment strategy for elderly patients with advanced rotator cuff arthropathy.

Clinical Message

Reverse shoulder arthroplasty with CT-based virtual implant positioning is a safe and effective treatment for elderly patients with massive irreparable rotator cuff tears and cuff tear arthropathy, enabling precise implant placement, excellent pain relief, and functional recovery.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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