Tips & Tricks: Arthroscopic Shoulder Arthrodesis in Young Patients with Brachial Plexus Injuries: Restoration of Shoulder Stability for Hand Positioning

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Introduction

Shoulder arthrodesis is a surgical procedure involving fusion of the glenohumeral joint and possible supplemental acromiohumeral fusion. The procedure was traditionally indicated in cases of significant trauma including brachial plexus injuries and massive irreparable rotator cuff tears with insufficient deltoid compensation, as well as cases of substantial bone loss following infection, tumor resection, or failed glenohumeral arthroplasty.[1] With the continuing evolution of shoulder arthroplasty and arthroscopy to address complex shoulder pathology, the indications for shoulder arthrodesis are diminishing. However, for the brachial plexopathy patient with retained or restored elbow and hand function without a stable shoulder, shoulder arthrodesis can be a life-changing procedure.[2]

Brachial plexopathies present a multi-disciplinary issue which often requires the involvement of microsurgeons, neurosurgeons, hand surgeons, and shoulder and elbow surgeons. Patients with upper or complete brachial plexus injuries suffer from loss of shoulder abduction, shoulder external rotation, and elbow flexion due to injury to the C5 and C6 nerve roots supplying the suprascapular, subscapular, axillary, and musculocutaneous nerves.[3] Up to 29% of brachial plexopathy patients present with isolated upper trunk injuries. The degree to which elbow flexion is affected is variable. However, the two most important goals of surgery are restoration of elbow flexion followed by shoulder stability.[3] Without intact elbow flexion, a patient with a surgically stabilized shoulder will still not be able to reach their head for feeding and personal hygiene. Prior to consideration of shoulder arthrodesis, microsurgery to repair the suprascapular and axillary nerves is often considered. Muscle or nerve transfers can also be used to improve shoulder abduction and external rotation.[2] Free functional muscle transfers such as a functional gracilis transfer for restoration of elbow flexion and rudimentary grasping have also been described when local and rotational muscle transfers have not adequately restored function.[4,5]

Shoulder arthrodesis is often indicated for shoulder stabilization in cases with retained elbow flexion or in conjunction with free functional muscle transfer or bipolar latissimus transfer in cases with loss of elbow flexion. The goal of shoulder arthrodesis is to stabilize the glenohumeral joint to allow for range of motion through the scapulothoracic joint and to position the elbow in space in such a way that the patient will be able to reach their hand to the mouth and to the perineum for hygiene. Successful shoulder arthrodesis requires intact periscapular musculature including a functional trapezius, levator scapulae, latissimus dorsi, serratus anterior, and rhomboid muscles to allow for motion through the scapulothoracic joint after arthrodesis.[6] The improvement in function provided by shoulder arthrodesis allows patients to independently complete activities of daily living.

Case Presentation

We present the cases of two young male patients who presented after sustaining brachial plexus injuries in motorcycle collisions. Patient A sustained his injury at age 20, two years prior to presentation. At the time of his injury, he also sustained a subdural hematoma and numerous orthopaedic injuries. EMG confirmed a left upper and middle truck brachial plexus injury with lower truck involvement to a lesser degree. He underwent brachial plexus exploration and lateral cord neurolysis with left phrenic nerve to musculocutaneous nerve transfer using sural nerve graft. Two months later he underwent a median nerve fascicular transfer to the brachialis branch of the musculocutaneous nerve (modified Oberlin procedure). At the time of presentation to our team, he had severe atrophy of the left upper extremity with some elbow flexion and some active

finger flexion. However, he was unable to reach his mouth with his left hand. Given the patient's lack of meaningful function of the left upper extremity the decision was made to proceed with arthroscopic shoulder arthrodesis twenty months after the initial injury (Figure 1).

Patient B sustained his injury at age 43, three years prior to presentation. In addition to his right brachial plexus injury, he also suffered numerous orthopaedic injuries and cervical spine fractures. Following the injury, Patient B was unable to abduct, adduct, flex, or extend his right shoulder. EMG confirmed a severe right upper and middle trunk brachial plexopathy. Patient B underwent right supraclavicular brachial plexus exploration, neurolysis, and nerve graft repair from C5 to the suprascapular nerve and upper trunk, and right ulnar nerve fascicular transfer to the biceps branch of the musculocutaneous nerve. He later underwent right radial to axillary nerve transfer. Fifteen months after initial injury the patient continued to have significantly limited right upper extremity function despite multiple surgical interventions and consistent physical therapy participation (Figure 2). The decision was then made to proceed with right arthroscopic shoulder arthrodesis.

Procedure

Both patients underwent the same positioning and approach. The patients were placed in the beach-chair position. The glenohumeral joint was visualized through a posterior portal. An anterior portal was then established. A shaver was used to debride the labrum circumferentially. A high-speed burr was then utilized to remove cartilage from both the humeral and glenoid articular surfaces. Special attention was paid to ensuring adequate cartilage removal from the areas of joint surfaces which correlated with the ideal fusion position given each patient's unique needs. The quality of the debridement was assessed by camera through both the anterior and posterior portals. A microfracture kit was employed to fenestrate the cortices under fluoroscopic guidance.

Attention was turned to proper alignment of the glenohumeral joint for functional arthrodesis. The glenohumeral joint was placed in approximately 30 degrees each of forward flexion, abduction, and internal rotation with minor adjustments made to accommodate for the patients' thin frames. Elbow range of motion was assessed to assure the patient would be able to bring the hand up to the head and down to the thigh. Patient A

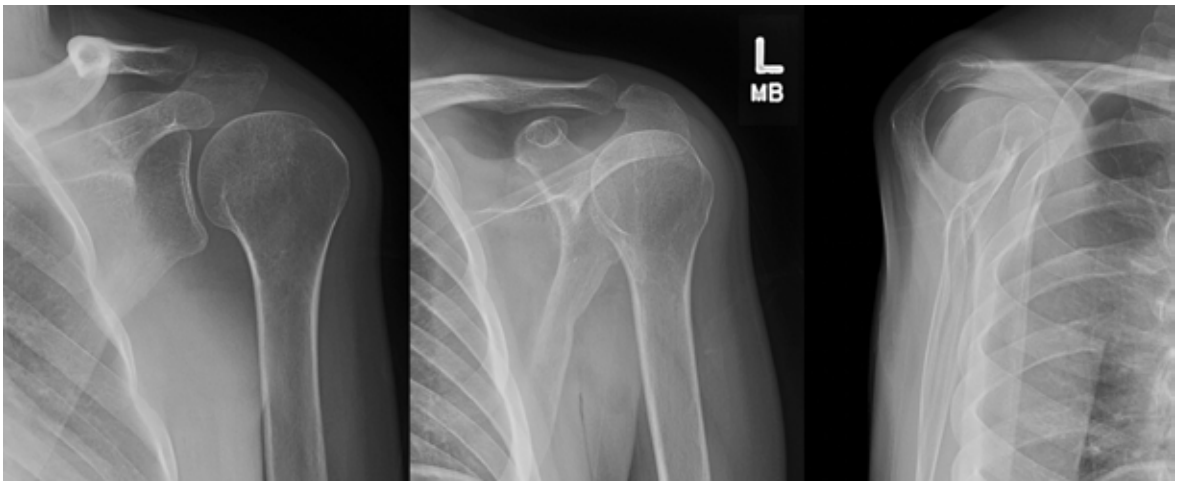

Figure 1. Pre-operative imaging of the left shoulder of Patient A demonstrating reduced humeral head without fracture.

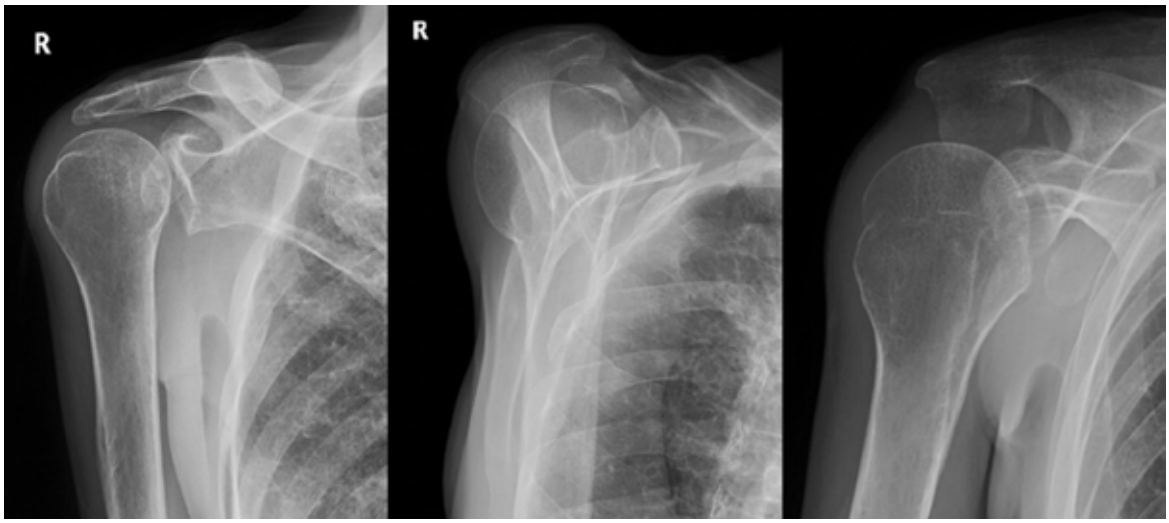

Figure 2. Pre-operative imaging of the right shoulder of Patient B demonstrating high-riding humeral head and right clavicle malunion.

required less internal rotation and more abduction than typical to allow for elbow flexion to meet the mouth given his significant motor deficits.

Fluoroscopy was utilized to template the starting point and trajectory of the screws that would be placed across the glenohumeral joint. Once the appropriate starting point was determined, an incision was made over the lateral humerus to allow for screws to be placed across the glenohumeral joint. For both patients a drill-tip guidewire and reverse drilling in between cortices were utilized which allowed for increased tactile feedback as each cortex was passed. Screw length was measured off the guidewire. Patient A was noted to have poor bone quality at the humeral head and had four screws placed across the glenohumeral joint. Three 6.5mm self-drilling, self-tapping, partially-threaded screws were placed with washers: one down the inferior angle of the scapula, one straight across the joint, and one through the upper portion of the joint. An additional 4.5mm screw was placed across the joint for reinforcement. Finally, a fully-threaded 6.5mm screw was placed from the acromion through the humeral head to the calcar.

Patient B also had placement of three 6.5mm self-drilling, self-tapping, partially-threaded screws with washers. However, given higher bone quality he did not require placement of a 4.5mm reinforcement screw across the glenohumeral joint. The first, more inferior, screw was placed just behind the bicipital groove along the greater tuberosity with 30 degrees retroversion. A second, more superior screw was then placed parallel to the first in the same fashion. A third screw was placed at the top of the greater tuberosity through the inferior angle of the scapula. To achieve rotational stability, a final fully-threaded 6.5mm screw was placed from the middle of the acromion to the calcar of the humerus.

The arthroscopic portals and screw incisions were then closed. Sterile dressings were applied. Patient A was placed in a bulky splint post-operatively. Patient B was placed in a sling. Both patients were awoken and transferred to the post-operative area without complication. Imaging obtained on the day of surgery demonstrated screw fixation of the glenohumeral joint with appropriate alignment (Figures 3 and 4).

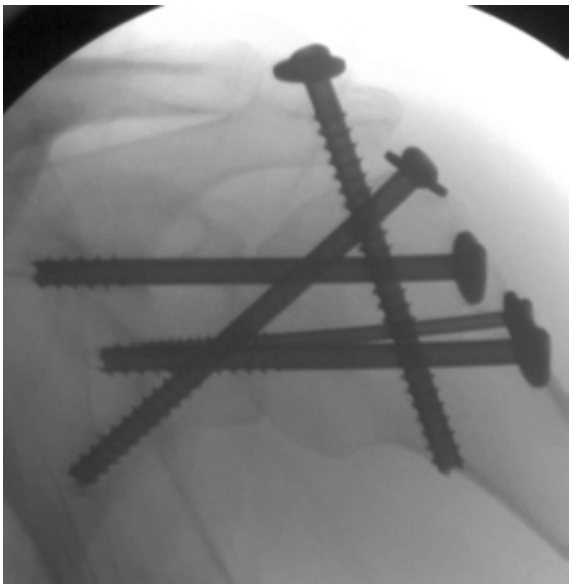

Figure 3. Day of surgery intra-operative imagining of the left shoulder demonstrating shoulder arthrodesis with screw fixation.

Figure 4. Day of surgery post-operative imagining of the right shoulder demonstrating shoulder arthrodesis with screw fixation.

Follow-up

Patient A had an uncomplicated post-operative course. His incisions healed well without any prominent hardware. Six weeks post-operatively the patient was able to reach his mouth with his hand. In the two years following arthroscopic shoulder arthrodesis the patient underwent wrist arthrodesis and multiple tendon transfers at the wrist and hand which further improved hand positioning and function. Imaging obtained 2.5 years after shoulder arthrodesis confirmed complete fusion of the glenohumeral joint with hardware retained in the appropriate position without evidence of failure (Figure 5).

At six-week follow-up Patient B was doing well and satisfied with his progress. His surgical incisions were well-healed. He was instructed to discontinue use of the sling and to continue to focus on elbow range of motion and strengthening. Imaging obtained at follow-up demonstrated appropriately aligned glenohumeral joint with evidence of early fusion. Hardware was well-fixed without out evidence of lucency or displacement (Figures 6). With consistent physical therapy the patient was able to flex the elbow to reach his mouth two months post-operatively.

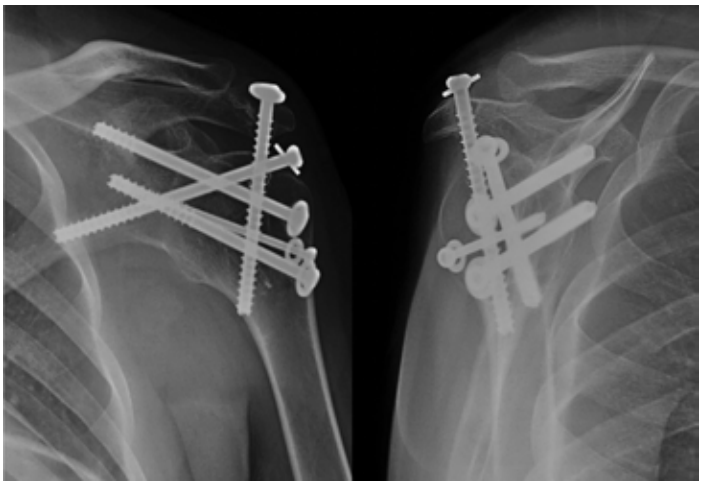

Figure 5. 2.5-year post-operative imaging of the left shoulder of Patient A demonstrating well-aligned glenohumeral arthrodesis with complete fusion of the glenohumeral joint.

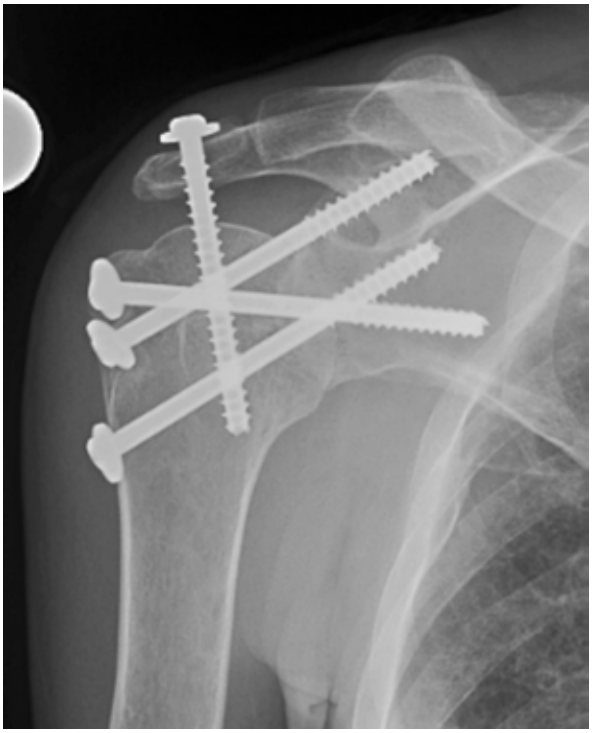

Figure 6. One-month post-operative imaging of the right shoulder demonstrating well-aligned glenohumeral arthrodesis with hardware in place.

Discussion

Traditionally, shoulder arthrodesis has been completed as an open procedure with utilization of a nonlocking plate over the humerus and scapular spine followed by an extended period of upper extremity immobilization.[6,7] Alternatively, shoulder arthrodesis has been performed arthroscopically with percutaneous screw placement across the glenohumeral joint with the addition of an external fixation device for added support while the fusion heals. We present the use of arthroscopic shoulder arthrodesis without the addition of external fixation in the setting of a traumatic upper brachial plexus injury.

Arthroscopic Arthrodesis

Arthroscopic arthrodesis is a minimally invasive alternative to the traditional open shoulder arthrodesis with lower likelihood of prominent hardware, risk of infection, elbow stiffness from prolonged immobilization, and post-operative humerus fracture caused by the stress riser at the distal end of a scapulohumeral plate, which have all been seen in other shoulder arthrodesis techniques.[1,7] Particularly for the young population most commonly affected by traumatic brachial plexopathy, arthroscopic surgery offers a cosmetic advantage over open arthrodesis. Additionally, these young patients generally have a biologic advantage which supports fusion following arthroscopic joint preparation without the necessity of open exposure of the joint.

There is a paucity of literature assessing the outcomes of arthroscopic shoulder arthrodesis compared to open shoulder arthrodesis; the literature that does exist is in the format of individual case studies or small case series.[1,8,9] The first case report of arthroscopic-assisted glenohumeral arthrodesis was published in 1992.[10] This case involved a 39-year-old woman with axillary nerve palsy, global left shoulder pain, and multidirectional instability following a traumatic shoulder dislocation seven years earlier. In this case the glenohumeral joint was visualized through a posterior portal and a curette was utilized through the anterior portal to debride hyaline cartilage from the joint surface. Next a motorized abrader was used to take the joint surface down to bleeding bone. The arm was positioned in 25 degrees of abduction, 30 degrees of forward flexion and 50 degrees of internal rotation as recommended by Rowe in 1983.[11] Two 6.5mm cannulated cancellous lag screws were placed across the glenohumeral joint, and a third screw was then placed from the acromion through the humeral head and neck. Screw placement was confirmed with fluoroscopy, portals were closed with suture, and the patient was placed in a foam abduction pillow. The arm was immobilized for four weeks at which point active range-of-motion exercises were initiated. At six weeks post-operatively the patient was able to reach her mouth and perineal area. Imaging at ten-weeks post-operatively confirmed glenohumeral fusion.

Other case reports have followed a similar operative technique. In 2008, Syal et al published a report of two cases of arthroscopic shoulder arthrodesis.[8] Their paper focused on cases of global shoulder instability which had failed numerous muscle and tendon transfers prior to consideration of shoulder arthrodesis. In this study the patients were placed in the beach chair position, and the standard posterior arthroscopic portal was used for visualization of the glenohumeral joint. The anterior portal was used to prepare the joint for fusion. The arm was positioned in 30 degrees flexion, 30 degrees abduction, and 30 degrees internal rotation. An anterior cruciate ligament (ACL) guide was utilized for placement of two guidewires across the glenohumeral joint. Two 6.5mm cannulated

screws were then placed over the guidewires. A third 6.5mm cannulated screw was placed from the acromion into the humeral head as was also demonstrated in our case. Screw position was confirmed with fluoroscopy. Post-operatively the patients were each placed in an abduction pillow for three months and they both went on to fusion.

Arthroscopic Arthrodesis with External Fixation

Alternative surgical options include arthroscopic joint preparation with placement of external fixation device as described by Lenoir et al.[9] In their case series they placed three external fixation pins in the scapular spine and three pins in the humeral shaft. They prepared the glenohumeral joint for arthrodesis, keeping in mind the ideal glenohumeral joint position of 30 degrees forward flexion, 30 degrees abduction, 30 degrees internal rotation for arthrodesis. All eight of the patients in their case series had two parallel 6.5mm screws placed across the glenohumeral joint. Two of the patients had an additional screw placed from the acromion to the humeral head due to concern for poor bone quality. The post-operative protocol included immobilization with an abduction pillow for 4 weeks followed by mobilization with physical therapy for the scapulothoracic joint. External fixation was removed after 2 months for all patients in the study. All patients in the study went on to fusion of the glenohumeral joint and had statistically significant improvements in the American Shoulder and Elbow Surgeons (ASES) index, Disabilities of the Arm, Shoulder and Hand (DASH) score, and the Simple Shoulder Test. When compared to casting or bracing, external fixation allows for scapulothoracic and elbow range of motion while selectively blocking scapulohumeral movement. However, an external fixation device can be uncomfortable for patients, require surgical removal, and adds the risk of pin loosening, pin track infection, and fracture at the pin sites.[7,8]

Open Arthrodesis

Traditional open glenohumeral arthrodesis can be performed in the beach chair position of lateral decubitus position based on the surgeon's preference.[6] The glenohumeral joint is accessed via a longitudinal incision beginning proximally at the glenoid fossa or scapular spine and extending distally past the acromion and continuing along to axis of the humerus. The deltoid is reflected to expose the scapula, acromion, and proximal humerus. Care is taken to preserve the axillary nerve when still functional. The rotator cuff and joint capsule are then reflected to expose the joint. The glenohumeral joint surfaces and inferior acromion are prepped with a combination of reamers and burrs. Controversy exists regarding the appropriate position of glenohumeral joint for optimal function, though the majority of sources agree it is most important that the arm be placed in a position which allows the patient to reach both the mouth and perineal area.[6,12,13] The preferred position of the humerus on the glenoid involves a combination of intra-articular and extra-articular positioning with the humerus aligned with the superior aspect of the glenoid and the inferior aspect of the acromion allowing for increased bone-to-bone contact.[6,13] A reconstruction, dynamic, or locked plate, screws across the glenohumeral joint, or external fixation device, or any combination of those fixation techniques is then used to secure the shoulder joint in the preferred position.[6]

While open glenohumeral arthrodesis has been the most common technique for shoulder fusion, there have been many documented complications. Plate fixation with open arthrodesis has been shown to cause skin irritation often necessitating hardware removal.[14] Nonunion rates of open glenohumeral arthrodesis are reported as high as 24%.[7,12] Additionally, Wagner et al reported a 21% humeral shaft fracture rate just distal to the plate used in open arthrodesis due to the stress riser created by the construct.[7] This leads to further immobilization and possible revision surgery. Infection following open glenohumeral arthrodesis has been noted in 4% to 12% of cases often necessitating additional surgery.[7,13-15] Three studies looking at shoulder arthrodesis complications found that 10% of patients required a revision surgery to perform a humeral osteotomy for correction of glenohumeral malpositioning which significantly delayed return to activity and limited functional recovery.[13,16,17]

Conclusion

Glenohumeral arthrodesis is a well-established procedure which can provide substantial improvement in upper extremity range of motion and function in patients for whom nerve and muscle transfers have failed to restore shoulder stability and function. Traditional open glenohumeral arthrodesis has shown success in restoring function and decreasing pain when appropriately indicated. However, open arthrodesis has consistently demonstrated high complication rates which often necessitate additional surgical procedures. Arthroscopic glenohumeral arthrodesis offers the benefits of open arthrodesis with a significantly less invasive procedure, less prominent hardware, and lower potential for infection or fracture. Arthroscopic shoulder arthrodesis can be utilized for restoration of shoulder stability as part of a multi-disciplinary approach to improve function of the upper extremity following brachial plexus injury.

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