Arthroscopic glenohumeral arthrodesis with o-arm navigation

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Abstract

Glenohumeral arthrodesis is an end-stage salvage operation that has traditionally been performed in an open fashion. In recent years an arthroscopic approach has been described. The purpose of this report was to present an arthroscopic glenohumeral arthrodesis technique with the assistance of O-arm-based navigation. An illustrative case example is presented. This technique allows not only a minimally invasive glenohumeral arthrodesis but also precise screw fixation by navigation, which may be particularly useful in cases of limited bone stock and/or bony deformity.

Reference


DOI : 10.1016/j.eats.2013.09.020
PMID : 24904761
Arthroscopic Glenohumeral Arthrodesis With O-Arm Navigation
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Abstract: Glenohumeral arthrodesis is an end-stage salvage operation that has traditionally been performed in an open fashion. In recent years an arthroscopic approach has been described. The purpose of this report was to present an arthroscopic glenohumeral arthrodesis technique with the assistance of O-arm–based navigation. An illustrative case example is presented. This technique allows not only a minimally invasive glenohumeral arthrodesis but also precise screw fixation by navigation, which may be particularly useful in cases of limited bone stock and/or bony deformity.

Glenohumeral arthrodesis is an end-stage surgical option indicated in cases of permanent brachial plexus injury, post-tumor resection, unreconstructable glenohumeral arthritis, chronic infection, and refractory instability with rotator cuff and deltoid dysfunction. Traditionally, the procedure has been performed in an open manner with screw and/or plate fixation.1–3

Arthroscopic glenohumeral arthrodesis has been described in a few cases.4–7 An arthroscopic approach to arthrodesis allows complete visualization so that accurate acromiohumeral and glenohumeral decortication can be performed while minimizing invasiveness. In cases of severe bone loss, the positioning of the screws is crucial and can be difficult with either arthroscopic or open surgery. The O-arm (O-arm Surgical Imaging System and StealthStation S7; Medtronic, Minneapolis, MN) is a recently introduced real-time 3-dimensional imaging technology that may be useful in cases in which hardware positioning is needed to avoid neurovascular injury or in cases of limited bone stock.

The purpose of this report is to present a technique for arthroscopic glenohumeral arthrodesis assisted by O-arm–based navigation.

Technique

Under general anesthesia, the patient is placed on a carbon fiber table (Jupiter table; TRUMPF Medical Systems, Charleston, SC) in the lateral decubitus position, with circumferential access to the right shoulder and the operative arm draped free (Table 1). The arm is held with 5 to 10 lb of balanced suspension and positioned in 20° to 30° of abduction and 20° of forward flexion (Star Sleeve Traction System; Arthrex, Naples, FL). A posterior portal is first established. Notably, in cases of severe glenoid retroversion, it is necessary to place this portal from a more medial approach than the typical posterior portal (Table 1). An anterior portal is then established with an outside-in technique using a spinal needle as a guide. While the surgeon is viewing from the posterior portal and working from the anterior portal, and then vice versa, an electrocautery probe (VAPR Coolpulse Premiere 90 Electrode; DePuy Mitek, Raynham, MA) and a 4.5-mm burr (Bonecutter; Smith & Nephew, Andover, MA) are used to lightly denude the articular surfaces of the humeral head to bleeding subchondral bone. In the setting of significant glenoid bone loss, the glenoid is prepared with a curette and microfracture only to avoid further bone loss (Fig 1, Table 1, Video 1). In cases of glenoid bone loss, we do not attempt to achieve fusion between the humeral head and acromion (extra-articular fusion) because superior translation of the humeral head would lead to a loss of contact with the medialized glenoid.

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The authors report the following potential conflict of interest or source of funding: P.J.D. is a consultant for Arthrex.

Received September 6, 2013; accepted September 24, 2013.
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© 2014 by the Arthroscopy Association of North America 2212-6287/13655/536.00
http://dx.doi.org/10.1016/j.eats.2013.09.020

Arthroscopy Techniques, Vol 3, No 2 (April), 2014: pp e205–e209

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A reference with reflective marker spheres is fixed to the spine of the scapula through a mini-open approach (Fig 2). A sterile draped O-arm (O-arm Surgical Imaging System and StealthStation S7) is used to obtain a 3-dimensional computed tomography scan with a medium dose of irradiation, and a computer-assisted navigation system is used (Fig 3). The shoulder is held in a position of 30° of flexion, 20° of abduction, and 40° of internal rotation to mimic the previous position of the arm and the desired position for glenohumeral arthrodesis. With the arm held in the appropriate position, 3 to 4 guide-wires for 6.5-mm cannulated screws are percutaneously inserted from the humeral head into the glenoid and from the acromion to the humeral head with the guidance of intraoperative computer-assisted navigation (Fig 4) and under direct arthroscopic visualization. Anatomic landmarks are used to avoid injury to the neurovascular structures, particularly the axillary nerve laterally. The wires are then measured and reamed for placement of 6.5-mm cannulated cancellous screws. Before tightening of the screws, cancellous allograft bone chips are placed in the glenohumeral joint under arthroscopy with an osteochondral transfer system (Single-Use OATS; Arthrex). The screws are sequentially tightened to achieve adequate compression of the glenohumeral surfaces. The position of each screw is then verified with the O-arm.

Postoperatively, the patient is immobilized with a humeral abduction sling (Fig 5) for a period of 8 weeks. Active hand and elbow motion is allowed immediately. At 8 weeks, the sling is removed and scapulothoracic motion is allowed. Strengthening is allowed at 12 weeks, and full activity is allowed when radiographic healing is observed.

Case Example
A 52-year-old right hand–dominant woman presented with several years of constant right shoulder pain. She had a history of permanent obstetric brachial plexus palsy. Although she had done well previously, in recent years she had worsening pain that was affecting her quality of life. She reported never having the ability to reach her mouth with her hand. Her symptoms were

Table 1. Tips and Pearls

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<thead>
<tr>
<th>Tips and Pearls</th>
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<tr>
<td>A lateral decubitus position is required because the beach-chair position is not currently compatible with O-arm imaging.</td>
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<tr>
<td>In cases of severe glenoid retroversion, place the posterior portal from a more medial approach than the typical posterior portal.</td>
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<tr>
<td>In the setting of significant glenoid bone loss, prepare the glenoid with a curette and microfracture only.</td>
</tr>
<tr>
<td>In the case of extra-articular fusion, insert acromiohumeral screws through the approach used for reference.</td>
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Fig 1. Right shoulder with anterior viewing portal and posterior working portal. Because of the degree of bone loss, the glenoid is prepared with microfracture only to avoid further bone loss.

Fig 2. Intraoperative photograph of right shoulder. Before O-arm navigation, a fixed reference with reflective marker spheres is placed on the spine of the scapula.

Fig 3. Photograph showing acquisition of intraoperative computed tomography scan obtained with O-arm. The scan is used to plan the position of the screws.
refractory to extensive nonoperative treatment including injections, pain medication, and physical therapy. Her medical history was unremarkable, she was a nonsmoker, and she worked as a secretary. On examination, active and passive anterior forward flexion was 90°, external rotation with the elbow at the side was −40°, and internal rotation was at the hip. Motion at the glenohumeral joint was poor, with most of the motion occurring through the scapulothoracic articulation. Preoperatively, the visual analog scale score for pain, Constant score, and Single Assessment Numeric Evaluation score were each 10 points. Plain radiographs showed severe medialization of the humeral head and a laterally down-sloped acromion (Fig 6). Computed tomography scan showed posterior humeral head subluxation of 98%, poor glenoid bone stock, and grade IV fatty infiltration of the rotator cuff and deltoid (Fig 7).

Multiple treatment options were considered, but given the neurologic injury, it was believed that glenohumeral arthrodesis was the most appropriate surgical option. Arthrodesis was performed as described earlier. The total operative time was 122 minutes. No intraoperative or postoperative complication was noted. At 12 months postoperatively, the extent of active movement after arthrodesis was equal to the preoperative motion. The visual analog scale score for pain, Constant score, and Single Assessment Numeric Evaluation score improved to 2 points, 32 points, and 40 points, respectively (gain of 8 points, 22 points, and 30 points, respectively). The patient reported that she was very satisfied with the surgery and was able to move her right hand up to her face. Final radiographs showed maintained integrity and position of the hardware (Fig 8).

Discussion

Various techniques have been described for arthrodesis of the shoulder. Accepted fixation methods include external fixators, compression screws, or plates. Although screw fixation is biomechanically inferior to plate arthrodesis, there seems to have been a recent trend toward utilization of screw fixation alone, with or without an arthroscopic approach. Clinically, plate-based fusion has been associated with a higher rate of
infection, postoperative fracture of the humerus, and need for removal of hardware. Compared with an open approach, a minimally invasive arthroscopic approach carries a lower risk of infection, hardware prominence, and periprosthetic fracture. The addition of O-arm-based navigation to an arthroscopic technique may be advantageous, particularly in cases of limited glenoid bone stock, because it allows precise radiographic control of screw position.

However, the presented technique has limitations. First, we only performed an intra-articular fusion. Nevertheless, we believe that an extra-articular fixation could be realized in the same manner. Second, there is a lack of conclusive evidence as to whether screw or plate fixation is more appropriate for glenohumeral arthrodesis or whether there is a difference in outcome between arthroscopic and open approaches. More comparative studies are thus needed to determine the best treatment option. Third, the O-arm is an expensive tool and is associated with increased radiation to the patient.

Fig 6. (A) A preoperative anteroposterior radiograph of the right shoulder shows severe medialization of the humeral head and a laterally down-sloped acromion. (B) The scapular-Y view shows posterior subluxation of the humeral head relative to the glenoid.

Fig 7. A preoperative computed tomography scan of the same patient in Fig 6 shows posterior humeral head subluxation, limited glenoid bone stock, and grade IV fatty infiltration of the rotator cuff and deltoid muscles.

Fig 8. A postoperative anteroposterior radiograph 1 year after arthroscopic glenohumeral arthrodesis with O-arm navigation shows maintained integrity and position of the hardware. The arrow shows an acromiohumeral screw. A washer could have been beneficial to avoid countersinking the screw head in the soft bone.
and surgeon. Finally, many shoulder surgeons do not frequently use an O-arm device, so a learning curve may be expected.

Shoulder arthroscopic arthrodesis assisted by O-arm–based navigation allows minimal surgical aggression and presents, under particular circumstances, a suitable operative option.

References