



Tuberosity healing after reverse shoulder arthroplasty for acute proximal humerus fractures: the “black and tan” technique

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Background: Reverse shoulder arthroplasty has seen increased use for management of complex proximal humeral fractures in the elderly. Recent evidence has shown that tuberosity healing leads to improved active range of motion and functional outcomes. The purpose of this study was to report on the radiographic and clinical outcomes of a consecutive series of patients having undergone reverse shoulder arthroplasty for fracture utilizing the “black and tan” method—a hybrid cementation-impaction grafting technique that uses autogenous cancellous bone graft to create an interface between the proximal cement mantle and the area of tuberosity repair.

Methods: Twenty-five patients (average age, 77 years; range, 63-88 years) were included in the analysis with a mean follow-up of 17 months. All patients underwent reverse shoulder arthroplasty for a complex proximal humerus fracture using the black and tan technique.

Results: The tuberosity healing rate was 88%. At final follow-up, mean active elevation was $117^\circ \pm 23^\circ$, mean abduction was $86^\circ \pm 16^\circ$, and mean external rotation was $29^\circ \pm 18^\circ$. External rotation strength averaged 4.9 ± 0.2 . The Simple Shoulder Test and Single Assessment Numeric Evaluation scores averaged 7 and 76, respectively. The mean American Shoulder and Elbow Surgeons total score was 71; visual analog scale score for pain, 2; and visual analog scale score for function, 7. Of the 25 patients, 21 (84%) rated their satisfaction with the surgery as excellent or good.

Conclusions: The black and tan technique together with standard suture repair and an implant with features that support tuberosity repair results in a high tuberosity healing rate with restoration of external rotation after reverse shoulder arthroplasty for fracture.

Level of evidence: Level IV, Case Series, Treatment Study.

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Keywords: Reverse shoulder arthroplasty; proximal humerus fracture; black and tan; tuberosity healing

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Reverse shoulder arthroplasty (RSA) has become increasingly used for treatment of displaced, complex fractures of the proximal humerus in the elderly.²⁹ Tuberosity healing has been recognized as the most important factor affecting function after a hemiarthroplasty performed

for fracture, and multiple studies have reported on the poor functional results when nonunion, malunion, or resorption of the tuberosities occurs.^{5,7,8,16,31,36} However, only recently has the importance of tuberosity healing after RSA been recognized. Studies have shown that healing of the greater tuberosity results in improvements in active forward elevation,⁴ external rotation,^{4,14} and external rotation strength.²¹ As RSA gains popularity in fracture management, more emphasis on tuberosity repair for restoration of rotational shoulder function may be warranted.

Various surgical techniques have been developed in an effort to increase the likelihood of tuberosity healing after shoulder arthroplasty for fracture.^{1,13,19-21,24,25,27} The suture construct chosen for tuberosity repair is critical to prevent displacement and to maintain position of the fracture fragments.^{1,13} Implant design has been adapted to accommodate suture fixation to the stem, fins to resist rotational stress, and larger surface areas for tuberosity healing with bone-graft voids and ongrowth/ingrowth surfaces.^{19,24,25} Structural bone grafts have also been used to enlarge the area for tuberosity repair and healing potential.²¹ Last, partially cemented techniques for the humeral stem have been proposed to shield the intact proximal humerus and tuberosities from cement-induced thermal necrosis that may occur at the junction of the cement mantle and the tuberosities.^{20,23,32}

The “black and tan” technique has previously been described as a method of shoulder arthroplasty implantation; it creates a transition zone of bone graft between the cement mantle and proximal extent of the humeral shaft, thereby avoiding proximal thermal bone necrosis.^{20,32} The hypothesis of our study was that this technique would result in a high rate of greater tuberosity union and restoration of shoulder function. The purpose of this study was to report on radiographic and clinical outcomes of a consecutive series of patients having undergone RSA for fracture by the black and tan method.

Materials and methods

A retrospective query of a prospectively collected shoulder arthroplasty repository (Holy Cross Shoulder Outcomes Repository) was performed. All surgeries were performed by a single shoulder fellowship-trained orthopedic surgeon (J.C.L.) at a single institution between May 2010 and April 2014. The query identified 26 consecutive patients who were treated for complex proximal humerus fractures with a reverse shoulder replacement using the black and tan technique. No other technique was used in performing RSA for similar fractures. Patients were considered candidates for RSA if the proximal humerus fracture was not amenable to surgical fixation and tuberosity healing was thought to be unreliable with the use of a hemiarthroplasty. Patients were included if they had a minimum of 6 months of radiographic follow-up. Selection of a minimum 6-month radiographic follow-up was deemed necessary to observe tuberosity healing. One patient was excluded because of insufficient follow-up, leaving 25 patients included in this analysis.

Preoperative radiographs were examined to classify the fractures by the Neer classification, with specific attention directed to the degree of comminution of the greater tuberosity. Additional pathologic change, such as dislocation and glenoid fracture, was reported as well. Postoperative radiographs and clinical outcomes were reviewed from the most recent follow-up visit. Postoperative radiographs (anteroposterior, Grashey, axillary, and scapular Y) were evaluated for radiographic evidence of tuberosity healing by comparing initial postoperative radiographs with the most recent radiographs. Greater tuberosity healing was considered complete if there was no evidence of displacement of the tuberosity and trabeculation was noted between the humeral shaft and the greater tuberosity. Radiographs were also evaluated for radiographic lucency around the humeral stem by previously described methods.³⁵ Two reviewers (N.T.F. and N.G.E.) independently evaluated the radiographs.

At the most recent follow-up, patients completed the following patient outcome surveys: American Shoulder and Elbow Surgeons (ASES) pain, function, and total scores^{30,34}; Simple Shoulder Test²⁶; Single Assessment Numeric Evaluation³⁷; and visual analog scale (VAS) for pain and function.^{3,33} Measurements of postoperative active range of motion with a manual goniometry for forward elevation, abduction, and external rotation were performed by an independent observer (S.B.; see Acknowledgment). Internal rotation was measured by the reach test, identifying the highest midline lumbar or thoracic level obtained. To control for measurement bias, internal rotation measurements were then converted into 5 range segments of motion and converted into a 10-point scale.²² Manual strength was measured by the 5-point Oxford scale.

Surgical technique

All surgeries were performed using the black and tan technique²⁰ together with a standard method of tuberosity repair and a prosthesis (Monoblock Reverse Shoulder Prosthesis; DJO Global, Austin, TX, USA) with features that support tuberosity repair (textured plasma spray metaphyseal surface, suture holes, and fins).

The proximal humerus was routinely exposed through a deltopectoral approach, and the tuberosities were isolated and separated. The humeral head was then removed and taken to the back table, where morselized cancellous bone graft was harvested with a rongeur. Frequently, there was additional impacted cancellous bone within the medullary canal of the proximal humerus. This was carefully removed and saved along with the morselized graft from the humeral head. The glenoid was then exposed, and the baseplate and glenosphere were implanted.

Next, attention was directed to preparation of the tuberosities for suture fixation. Four types of suture alignments were used for suture fixation: horizontal (greater tuberosity to lesser tuberosity), vertical (greater tuberosity to humeral shaft), greater tuberosity to stem, and cerclage (through the medial hole of the stem and around both tuberosities). All sutures were passed at this time through the bone-tendon junction of the greater tuberosity.

The intramedullary canal was then gently sounded with intramedullary reamers to define the diameter of the humeral canal. The final reamer diameter defined the size of the cement restrictor that was eventually used during cementing. Broaches were then placed such that the medial aspect of the broach lined

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