

Radioulnar Heterotopic Ossification After Distal Biceps Tendon Repair: Results Following Surgical Resection

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Purpose: The purpose of this study is to evaluate the clinical outcome of patients who had excision of a radioulnar heterotopic ossification (HO) as a complication of a distal biceps tendon repair. The hypothesis is that there are no measurable clinical losses that persist after excision.

Methods: Eight consecutive patients were identified between 1996 and 2005. All were treated with HO excision using a standard surgical technique and rehabilitation protocol. These individuals were studied and compared to a matched cohort of 8 patients who had a distal biceps tendon repair with a similar surgical technique that was uncomplicated. All study patients were evaluated at a minimum 1-year follow-up with physical examination, isokinetic dynamometry, and outcome measures. Comparisons were made both between groups as well as side-to-side within groups.

Results: At follow-up examination, the mean arc of forearm rotation in the HO group measured 151°. The mean arc of forearm rotation in the control group measured 165°. With the numbers available, no measurable differences in arc of motion were identified between groups ($p > .05$). When compared to the normal, uninvolved side, patients who developed HO lost an average of 9° of forearm pronation ($p < .01$). No differences were identified between the HO and control groups with respect to isokinetic torque, endurance strength, or Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire (American Academy of Orthopaedic Surgeons, Rosemont, IL) scores ($p > .05$).

Conclusions: When patients develop motion-limiting HO after distal biceps tendon repair, surgical resection can lead to a functional recovery of elbow and forearm motion. Biceps strength can be maintained with no measurable differences in clinical outcome when compared to individuals who do not suffer this complication following distal biceps repair. (J Hand Surg 2007;32A:1230–1236. Copyright © 2007 by the American Society for Surgery of the Hand.)

Type of study/level of evidence: Therapeutic III.

Key words: Distal biceps, heterotopic ossification, isokinetic dynamometry, radioulnar synostosis, 2-incision technique.

Traumatic rupture of the distal biceps tendon is a rare injury, comprising approximately 3% of all ruptures of the biceps with an overall incidence of 1.2 per 100,000 persons per year.^{1,2} Direct repair of the biceps tendon to the radial tuberosity has been demonstrated to improve strength and function.^{3,4} The procedure is not without potential complications, however, with one of the most devastating being the development of motion-limiting heterotopic ossification (HO) between the radius and the ulna. This complication was initially attributed to the

surgical approach in a 2-incision technique in which both the radius and ulna were exposed.^{5,6} The development of radioulnar HO and synostosis, however, has also been reported in muscle-splitting 2-incision exposures of the tuberosity and much less frequently when a single anterior exposure is used for repair.^{1,3,4,6–18}

Once motion-limiting heterotopic bone forms, surgical resection can improve clinical outcome.^{16,19–22} This procedure, however, carries the risk of neurovascular injury and can lead to disruption of the

original distal biceps tendon repair.²³ This study reports on a group of patients treated with surgical resection of motion-limiting HO that occurred following distal biceps tendon repair. A lateral surgical approach was used without exposure of the radial nerve. Outcome is assessed using standardized tools including isokinetic dynamometry. In addition, we asked whether the development of this complication compromises ultimate upper extremity strength and function, compared to patients who had an uncomplicated distal biceps tendon repair. Our hypothesis is that, after excision, there are no measurable clinical losses in patients who develop motion-limiting HO after distal biceps tendon repair. Information on ultimate strength and function in this patient population is not currently available in the literature.

Materials and Methods

Eight patients who developed motion-limiting HO between the proximal radius and ulna as a complication of a distal biceps repair were referred for evaluation and treatment by the senior author between 1996 and 2005. All patients had their original repair performed using a 2-incision technique. Six had the tendon inserted into a bony trough using transosseous sutures. Two patients had the repair performed with the use of bone anchors. Two operative reports described a muscle-splitting lateral approach to the tuberosity.^{5,12} The 6 remaining operative reports lack detail regarding the initial lateral exposure. Patients ranged in age from 31–48 years, with a mean age of 40 years. All were men. The mean time between the original injury and primary repair was 14 days. No patients were initially treated with any prophylaxis for HO.

At presentation, the average preoperative arc of elbow motion was 127° (range, 115° to 135°). Preoperative forearm rotation was absent in 2 individuals with a complete radioulnar synostosis, and averaged a total of 25° in the other 6 patients with motion-limiting radioulnar HO. Seven of the 8 patients were laborers who sustained the injury at work, and 1 patient injured the arm at home. Five of the 8 patients sustained the injury to the dominant arm.

All patients had radiographic evaluation of the elbow and proximal forearm using plain radiographs including oblique views. Advanced imaging was not used. All patients were noted to have developed heterotopic bone between the radius and the ulna at the level of the radial tuberosity (Figs. 1A and 1B). There was no ectopic bone involving the radiocapitellar or ulnohumeral articulations. Surgical resection

was performed when the heterotopic bone appeared mature, as defined by sharp cortical margins on plain radiographs.^{24,25} The average time from the initial surgery to surgical resection was 6 months (range, 4 to 9 months).

All patients had a resection of the HO using a standardized approach. After administration of a long-acting regional block, the previous lateral incisions were extended proximally and distally, and the anconeus-extensor carpi ulnaris interval was defined. Blunt dissection was carried down to expose the supinator and the lateral border of the ulna. Care was taken to keep the dissection distal to the radial head and thus distal to the lateral ulnar collateral ligament insertion. Dissection was then performed from posterior to anterior, elevating the insertion of the supinator off the ulna to expose the HO. Subperiosteal elevation was continued until the radial shaft was exposed. Care was taken to define a normal interosseous space proximal and distal to the heterotopic bridge. Intraoperative fluoroscopy was used in all cases.

The bony bar was resected with a variety of instruments including rongeurs, osteotomes, and a low-speed burr. In an effort to maintain the integrity of the previously repaired tendon, the resection was performed in supination as much as possible, and care was taken to develop a concavity in the ulna opposite the tuberosity to allow for full pronation (Fig. 1C). In no cases did the biceps tendon insertion require release. All motion-limiting bone was resected from this approach until full rotation was restored on the table (Figs. 1D and 1E). The posterior interosseous nerve was not exposed in any case. Once full passive motion was achieved, the fascia and soft tissues were closed in the usual manner over a drain.

After surgery, all patients were placed into immediate, continued passive motion, taking the forearm through rotation. Formal therapy was begun on the morning following surgery and included edema control modalities, active and passive range of motion exercises, and patient-adjusted static bracing of the forearm. Each patient was treated after surgery with a single dose of external beam radiation (700 cGy) provided on postoperative day one. In addition, all patients were treated with oral Indomethacin (Merck & Co., Inc., Whitehouse Station, NJ) for a total of 3 weeks.

In an effort to compare the outcome of these patients with those who had an uncomplicated primary distal biceps repair, a control group of 8 men was identified from the records of the senior author. Every distal biceps repair performed during the study



period was reviewed, and these individuals were matched with the HO group for age, follow-up interval, dominance, etc. Their average age was 44 years (range, 36–52 years). All control patients were treated for acute distal biceps repairs with a 2-incision technique. Four of the 8 control patients injured the dominant arm.

All patients from both the study and control groups had follow-up examinations specifically for the purposes of this study. Institutional review board approval and informed consent was obtained. Patients were evaluated by an independent examiner in all cases. Each patient completed a 30-item Disabilities of the Arm, Shoulder and Hand (DASH) outcomes questionnaire (American Academy of Orthopaedic Surgeons, Rosemont, IL), which was scored by the formula $25 \times [(\text{sum of } n \text{ responses}/n) - 1]$. All patients had elbow and forearm range of motion measurements obtained of both the affected and unaffected extremities using a standard goniometer. Forearm rotation was measured with the arm at the patient's side and the elbow flexed to 90° while gripping a pen in each hand.

All patients had isokinetic strength in elbow flexion and forearm supination evaluated at the final follow-up examination, using the CYBEX Extremity System 340 Isokinetic Dynamometer (CYBEX International, Inc. Medway, MA). Patients were instructed not to participate in any workouts or activities that would stress the biceps for 48 hours prior to the evaluation. Before the strength testing, each patient was allowed 3 minutes of low-intensity warm-up on a hand bicycle. Patients were positioned supine for elbow flexion and sitting upright for forearm rotation. The machine's axis of rotation was aligned with that of the elbow joint and the forearm, respectively. Because there was no clear consensus regarding the ideal testing parameters for this population, a protocol was chosen based on those most commonly used in the literature.^{1,3,4,7,13,14,26–29} Five low-intensity repetitions to become familiar with the angular velocity were allowed prior to each velocity and position change. Patients were instructed to use maximal exertion and speed on each and every repetition of

testing. The protocols for both elbow flexion and forearm supination were identical and consisted of 1 set of 3 repetitions at an angular velocity of 90° per second, from which the value for the single highest peak torque was recorded, and a second set of 15 repetitions at an angular velocity of 240° per second, from which a fatigue index was calculated to estimate endurance. The fatigue index is defined as the percentage of decline in work done during the last 20% (3 repetitions in this protocol) compared to the first 20% of the set. The result is calculated by the formula $100 \times [1 - (\text{work over last 20\%} / \text{work over first 20\%})]$. Positive values reflect a decrease in work done over time, whereas negative values reflect an increase in work. The peak torque set for each exercise was always performed prior to the fatigue set. Subjects were given 45 seconds rest after each set.

Comparisons between the control and HO groups were performed using the Mann-Whitney U test. Side-to-side comparisons within each group were performed using the Wilcoxon signed-rank test. Inclusion of 8 HO and 8 control patients ensured 80% power for detecting a difference between the HO and control populations, if the probability that a measurement from 1 population is less than a measurement from the other population is 0.904, based on a 2-sided Mann-Whitney test with a 0.05 significance level.

Results

The 8 members of the HO group were evaluated at a mean follow-up interval of 57 months (range, 12–120 months). No HO patients were lost to follow-up examination. The control group of 8 patients was evaluated at a mean follow-up interval of 56 months (range, 12–129 months). Although the study was limited by the small sample sizes, there were no differences in age or length of follow-up interval between the HO and control groups ($p > .05$).

Heterotopic Ossification Group

There were no intraoperative or postoperative complications following HO excision, and no patients

Figure 1. (A) Oblique and (B) lateral radiographs demonstrating mature heterotopic bone between the proximal radius and ulna that developed as a complication following a distal biceps tendon repair. This typically forms at the level of the bicipital tuberosity. (C) Intraoperative photograph following resection of the heterotopic bone. Note exposure of the ulna and the radius with reconstitution of the interosseous space. Full forearm rotation is documented on the table prior to closure. (D) Oblique and (E) lateral radiographs obtained after surgery. Note the absence of heterotopic bone and the slight concavity in the ulna opposite the radial tuberosity to allow for full forearm pronation without compromise of the biceps tendon insertion.

required further surgery on their upper extremity. All 8 patients returned to work without restrictions at an average of 10 weeks (range, 3–23 weeks) following their release surgery.

At follow-up examination, mean elbow motion in flexion and extension measured 3° to 135° in the affected elbow versus 4° to 136° on the contralateral side ($p > .05$). Mean supination at final follow-up examination measured 86° (range, 64° to 105°) and mean pronation measured 65° (range, 50° to 78°). These were both improved from measurements obtained prior to HO resection ($p = .01$). Although the study was limited by the small sample size, when compared to the normal arm, only forearm pronation was measurably decreased, averaging 74° (range, 64° to 82°) on the unaffected side ($p < .01$).

Mean peak torque in flexion on the affected side averaged 61 Nm. Mean peak flexion torque on the control side averaged 57 Nm. These differences were not significant ($p > .05$). Mean peak supination torque measured 11 Nm on the affected side and 9 Nm on the control side. These differences were also not significant ($p > .05$). The mean fatigue index for flexion in the affected and unaffected arms revealed decreases in strength of 20% and 17%, respectively, over time ($p > .05$). Strength by supination fatigue index decreased 10% over time in the affected arm versus a 13% decrease in the unaffected arm. This difference was not significant ($p > .05$). The mean DASH score in the HO group at the final follow-up examination measured 11 (range, 0–26). The aforementioned comparisons are limited by the small sample size.

Control Group

At the follow-up examination, mean elbow motion in flexion and extension measured 0° to 131° in the affected elbow versus 1° to 134° on the contralateral side ($p > .05$). Mean supination at the final follow-up examination averaged 89° (range, 83° to 95°) and mean pronation measured 75° (range, 65° to 86°). No differences in motion were observed when the af-

ected arm was compared to the contralateral control limb ($p > .05$).

Mean peak torques in flexion and supination measured 53 Nm and 9 Nm, respectively, in the affected arm. These values measured 53 Nm and 11 Nm in the contralateral arm, respectively. No side-to-side differences in mean torque were identified ($p > .05$). The mean fatigue index for flexion demonstrated decreases in strength of 21% in the affected arm and 18% in the unaffected arm over time ($p > .05$). Supination fatigue strength decreased over time by 25% in the affected side and by 16% on the control side. This difference was not significant ($p > .05$). The mean DASH score in the control group at the final follow-up examination measured 4 (range, 0–15).

Comparison Between Groups

When the affected limbs of the HO group were compared to the control group's affected limbs, there were no significant differences identified in range of motion at final follow-up examination ($p > .05$) (Table 1). When isokinetic strength testing was compared between groups, no differences were identified in peak torques or fatigue indices ($p > .05$). The mean DASH score demonstrated a trend toward worse outcome in the HO group, but this difference was not significant ($p = .09$). At the follow-up examination, all patients in both groups were able to return to their previous occupations.

Discussion

Motion-limiting HO is a rare but well-documented complication following distal biceps repair, with a reported incidence of 1% to 8%.^{1,3,4,7–16,30,31} It occurs most commonly with 2-incision techniques. To our knowledge, there have only been 2 series describing outcomes after takedown of HO resulting from a distal biceps repair. Failla et al¹² presented 4 cases of HO that occurred after 2-incision biceps repairs. All were treated with excision of the HO, 2 with placement of an interposition silicone sheet.

Table 1. Clinical Results

Group	Supination (Deg)	Pronation (Deg)	Peak Torque Flexion** (%)	Peak Torque Supination** (%)	Fatigue Index Flexion*** (%)	Fatigue Index Supination*** (%)	DASH
HO Group	86 ± 12	65 ± 12*	8 ± 16	5 ± 31	20 ± 8	10 ± 26	11 ± 9
Control Group	89 ± 4	75 ± 8	1 ± 13	7 ± 37	21 ± 13	25 ± 27	4 ± 6

*Pronation was significantly less than that of the unaffected arm ($p < 0.01$).

**Calculated by the formula [(Affected / Unaffected) × 100] – 100, with peak torque measured in Nm.

***Calculated by the formula $100 \times [1 - (\text{work over last 20\%} / \text{work over first 20\%})]$.

Two of the 4 cases of HO recurred. Of the 2 patients with good outcomes, only 1 was able to achieve an acceptable, functional arc of forearm rotation. There was no description of objective strength measurement or functional assessment in this series.

Sotereanos et al¹⁶ more recently published a report of 8 patients who had resection of HO that developed following distal biceps tendon repair. All patients received 700 cGy of local irradiation and aggressive physical therapy beginning 24 hours after surgery. Their operative technique was similar to ours except that they visualized and performed a neurolysis of the posterior interosseous nerve through a separate muscular interval, whereas in our study the nerve was not identified. At an average of 27 months after surgery, they reported a mean total arc of forearm rotation of 155°. The authors mention that supination strength in the affected extremity was 80% of that of the contralateral limb, but there is no data provided as to how this was measured.

We report on 8 patients who had HO resection through a more limited lateral approach. By elevating the supinator off the ulna, the posterior interosseous nerve was protected and not separately exposed. No nerve deficits occurred using this approach. At an average follow-up interval of 57 months, all patients recovered near full forearm rotation with an average 151° arc. This is comparable to that obtained by Sotereanos et al. We did, however, identify a loss of 9° of final pronation, when compared to the normal, uninvolved side ($p < .01$). The functional significance of this pronation loss is not clear. Isokinetic strength testing showed no side-to-side differences in flexion or supination torque or fatigue at the follow-up examination.

When compared to a cohort of patients who had uncomplicated distal biceps tendon repairs, there was a trend toward worse functional outcomes when measured by DASH scores. The 2 patients in the HO group with DASH scores over 20 (mean of 11 for the group) had an average of 53° pronation (mean of 65° for the group). It is feasible that the limited pronation in these patients was a main contributor to their poorer functional outcome on the DASH index. Isokinetic testing of the involved side, however, revealed no measurable differences in strength or endurance between patients who had an uncomplicated biceps repair and those who developed motion-limiting heterotopic bone requiring surgical excision. As quantified in the results, it is notable that the affected arm in both groups was able to achieve supination

strength nearly identical in magnitude to that of the unaffected contralateral side.

The primary weakness of this study relates to the relatively small sample size, which is attributable to the rarity of the complication. It is possible that further differences might have been detected with a greater number of patients, decreasing the chance of Type II error. Nonetheless, our results suggest that patients who undergo resection of motion-limiting HO as a complication of a distal biceps repair can reliably regain a functional range of motion, retain their biceps strength, and return to their original level of work. Although they require a second operation and prolonged rehabilitation, their ultimate strength and function do not appear to be compromised by this complication.

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