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Anatomical intramedullary distal biceps tendon fixation. Our first experience

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Background: Intramedullary fixationvn in distal biceps tendon repair has been proposed to address specific shortcomings of current fixation techniques. Previous studies described a nonanatomical repair.
Hypothesis: The purpose of the present study is to report the short-term outcomes of an anatomic intramedullary fixation.
Study Design: We evaluated functional and radiographic outcomes up to 6 months of follow-up.
Methods: Patients with an acute distal biceps tendon rupture eligible for surgical repair were invited to take part in the study. Eleven patients were included in the final analysis. All patients were evaluated both clinically and radiographically at 2 weeks, 6 weeks, 3 months, and 6 months. Outcomes were recorded using the visual analog scale score for pain, the Mayo Elbow Performance Score, and Disabilities of the Arm, Shoulder, and Hand scores. The radiographic evaluation comprised X-ray and CT evaluation.
Results: There were no failures of fixation in the patient group examined. Elbow mobility was symmetric for all patients from 6 months onward. Supination strength was similar uninjured side at final follow-up. Mean Disabilities of the Arm, Shoulder, and Hand score and Mayo Elbow Performance Score at final follow-up were 0 and 100, respectively. Computed tomography images showed no signs of button migration, cortical thinning due to button pressure or button breakout. The tendon could be followed to the button in all cases. One case of heterotopic ossification was seen.
Conclusions: Anatomical intramedullary fixation of the DBT has excellent functional outcomes at 6 months. The anatomical repair resulted in a restoration of supination strength. This technique allows the anatomical reinsertion of the distal biceps tendon while minimizing the risk of PIN injury. The intraosseous position of the tendon avoids gap formation. No adverse reactions of the button on the bone were seen.

Early primary repair of distal biceps tendon (DBT) ruptures is usually indicated in complete ruptures, to ensure optimal recovery of supination and flexion strength and endurance.[3,12] Single-incision and double-incision approaches have been described. Single-incision techniques have gained popularity due to the lower risk of heterotopic ossification and radio-ulnar synostosis compared to double-incision techniques.[1,14,25] Fixation devices with a high initial load to failure[17] allow early range of motion and loading immediately after surgery. The bicortical button as described by Bain et al. offers the highest load to failure.[2] The bicortical button technique does not allow the anatomic reinsertion of the DBT as it would put the posterior interosseous nerve (PIN) at significant risk for entrapment behind the cortical button with PIN palsies being reported in up to 1.6%.[1,6,16] A more anterior reinsertion on the radial tuberosity is advised in order to protect the nerve. This reduces the final supination strength as the radial edge of the tuberosity, which acts as a fulcrum point for the DBT, is removed by the drill bit used to make the bone tunnel.[5,22] We recently proposed an intramedullary fixation device, which theoretically allows the anatomical reinsertion without risk for the PIN.[8,9] The first reported

Institutional review board approval was received from the Ethics Committee of Ziekenhuis Oost-Limburg.

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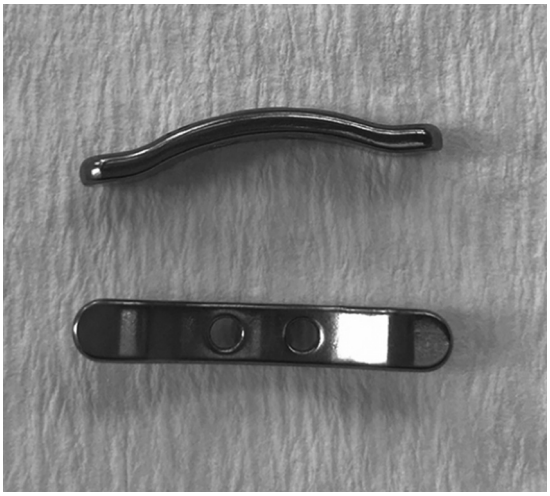

Figure 1 The fixation device.

results were favorable. These results were based on a non-anatomical reinsertion.[9] To date, however, no evaluation of the anatomical reinsertion has been performed.

The purpose of the present study is to evaluate the short-term outcomes of the anatomical reinsertion using this intramedullary fixation device.

Material and methods

Patient selection and follow-up

This is a retrospective case-control study performed in a single center. After internal review board approval, 11 consecutive DBT repairs were included. All patients were male. All patients had a complete distal biceps tendon rupture. Patients were seen at 2 weeks, 6 weeks, 3 months, and 6 months follow-up. Passive and active range of motion of the elbow and forearm were measured using a handheld goniometer. The distance from the elbow crease to the biceps muscle belly was measured at every follow-up (biceps crease interval). From 6 weeks onward, supination strength was measured in full supination with the elbow in 90° of flexion using a pronation-supination dynamometer (Baseline® hydraulic wrist dynamometer, Arex). Strength measurements were noted as a percentage of the contralateral side. The functional evaluation included the Mayo Elbow Performance Score (MEPS), the Dutch version of the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, and the visual analog scale for pain both in rest and with active biceps contraction. The MEPS is a widely applied measure of the function of the elbow. It is a clinician-completed score that includes 4 categories: pain, motion, stability, and the ability to perform 5 functional tasks. The DASH score is a validated patient-oriented rating scale that analyzes factors involved in activities of daily living, followed by optional questions. Possible complications such as LACN neuropraxia, PIN damage, heterotopic ossification and rerupture rates were recorded. Radiographic evaluation was performed at 2 weeks and 3 months postop to ensure correct positioning of the button. A CT scan was done at 6 months to evaluate implant positioning and the effect of the button on the anterior cortex by comparing it with the preoperative radiographs. Furthermore, cortex closure around the tendon and cortex reaction to the button was evaluated by measuring the drill hole width at the outer edge of the anterior cortex and the button. The distribution of variables is given as mean, standard deviation, and range.

Button design

The button design was used following the previous reported dimensions[8] and printed in titanium by a commercial company specialized in titanium implants for maxillofacial surgery. (Fig. 1) The design features a bell shape with an offset height of 3 mm at its center to allow insertion of the button through an 8 mm drill hole on the proximal cortex. The button has a width of 4 mm and a length of 24 mm to span the radial tuberosity. This length also allows purchase on the thick cortical bone alongside the thinner bone of the tuberosity.

Surgical technique

Surgical exploration was performed through a 3-cm longitudinal incision starting centrally 3 cm distal to the elbow crease and extending distally. In case of marked proximal retraction or adherence of the distal biceps tendon stump, a secondary 1 cm incision was made at the site of the stump, and the tendon was passed distally to the initial incision. After débridement of the biceps tendon to healthy tissue, a partially absorbable suture (FiberLoop 2; Arthrex, Naples, FL, USA) was passed in a whipstitch fashion in the distal 20 mm of the tendon so that its ends emerged at the distal tendon end. With the forearm held in hypersupination, a guide pin (1.6 mm Kirshner wire) was drilled through the radial tuberosity starting as far ulnar as possible, aiming oblique toward the radial cortex until it touched the opposite cortex. The angle to the bone needs to be at least 45°. This creates a hole in the medullar canal in which the device can be inserted. A too shallow angle would not create a hole but would ream the cortex. As we could not drill the guidewire and reamer in the posteromedial facet of the tuberosity with a great enough angle, the native site of tendon insertion could not be achieved but was approximated as close as possible. The aim was to reinsert the tendon as ulnarly as possible with the cam of the tuberosity preserved. Care was taken that the drill guide did not perforate the opposite cortex to prevent damage to the posterior interosseous nerve. The guidewire was then over-reamed through the anterior cortex with an 8 mm cannulated drill bit. The depth of this bone tunnel was to the posterior cortex. Extensive lavage with 500 ml of saline was performed after the removal of visible bone debris. The intramedullary canal was opened with the use of a curved clamp. Next, the button was loaded on the free suture ends of the FiberLoop suture-tendon construct. The button was then inserted into the bone tunnel using a mosquito clamp. The button was centered under the bone tunnel by pulling on both sutures simultaneously. In this way, the button flips to engage the anterior cortex of the radial tuberosity. Once the button was positioned correctly, the tendon was pulled into the radius by pulling both sutures separately, using the tension slide technique described by Sethi.[23] One of the suture ends was passed through the tendon with a free needle and then tied to the remaining suture end onto the button using a knot pusher. Fluoroscopy was used to confirm the correct final position of the button. Prior to wound closure, further rinsing and hemostasis were performed. Active and passive mobilization was allowed the day after surgery. Physiotherapy was started from 2 weeks onward. Muscle strengthening commenced at 2 months postoperatively. A controlled, unlimited lifting was allowed at 3 months. Sports activities were allowed at 5 months.

Results

All patients had a trauma mechanism suggestive of excessive eccentric loading of a flexed and supinated arm. Patient demographics are listed in Table I. The average age was 46 years (range 42-61). The mean time to surgery was 4 days for the patients

Table I
Demographics, functional, and clinical outcomes.

Variable	Demographic data	Outcomes			
		2 weeks	6 weeks	3 mo	6 mo
Age	46 ± 9				
Male sex	11				
Side					
Dominant	7				
Nondominant	4				
Extension °		10 ± 9	1	0	0
Flexion °		135	135	135	135
Pronation °		50 ± 12	80 ± 3	88 ± 1	90
Supination °		90	90	90	90
Supination strength (%)		/	57% ± 25	78% ± 14	99% ± 2
Biceps crease distance (CM)		2,4 ± 0,2	2,4 ± 0,2	2,4 ± 0,2	2,4 ± 0,2
DASH		29 ± 20	4 ± 6	1 ± 4	0
MEPS		86 ± 6	98 ± 4	100	100

DASH, Disabilities of Arm, Shoulder, and Hand; *MEPS*, Mayo Elbow Performance Score; PEEK.
Continuous data are shown as the mean ± standard deviation and categoric data as number.

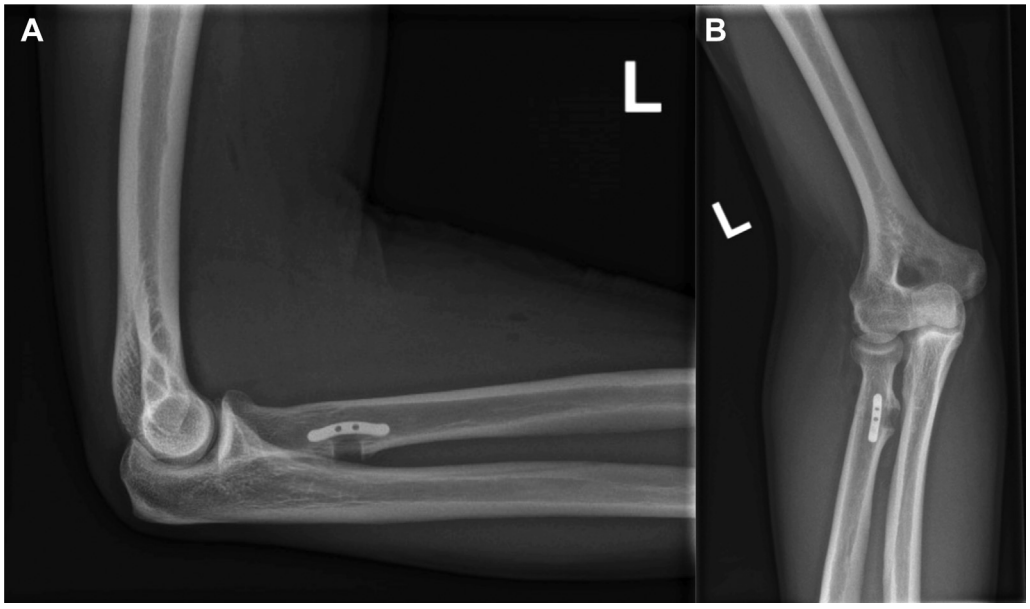

Figure 2 (**A** and **B**) Radiographic follow-up at 2 weeks. No signs of cortex breakthrough and centralization of the button at the drill hole.

with complete ruptures (range, 1-8 days). Four patients (36%) experienced temporary hypoesthesia in the innervation area of the lateral antebrachial cutaneous nerve. This was resolved in all cases. Heterotopic ossification was seen in one patient (9%). As the ossification did not limit motion or function, no further treatment was required. At 2 weeks after surgery, all patients had full elbow flexion and supination. The average active (and passive) extension deficit at 2 weeks was 10° (range 0°-20°). One patient had an extension deficit of 5 degrees at 6 weeks. All patients recovered full extension at 3 months postoperative. An average active pronation deficit of 40° (range 0°-70°) was present at the 2-week follow-up. An average active pronation deficit of 10° (range 0°-35°) was present at the 6-week follow-up. At 3 months one patient still had a pronation deficit of 10°. All patients recovered full active and passive pronation 6 months postoperatively. The average VAS score for pain at 2 weeks after surgery was 1 (range 0-2) in rest and 4 (range 3-6) with active supination. No patient experienced pain at 6 weeks after surgery. The average biceps crease interval was 2,8 cm (range 2 cm-3 cm) and was constant in each patient in every follow-up. The average supination strength at 6 weeks was 57% (range 40%-81%), 78% at 3 months (range 62%-90%) and 99% (range 92%-107%) at 6 months. One patient had shoulder surgery at the same side 6 weeks after the distal biceps repair, which made strength testing at 3 months impossible. At 6 months after surgery, strength was still less than the contralateral side (89%). Radiographic evaluation at 6 weeks showed no migration of the button or button breakout. No adverse cortical reactions were noted. CT evaluation of the proximal radius was performed 6 months after surgery in all patients. There were no signs of button migration, cortical thinning due to button pressure or button breakout. Average drill hole width was 7.7 mm (range 7.5 mm-8 mm) at the outer edge of the anterior cortex and 7.5 mm (range 7.2 mm-7.8 mm) at the button.

Discussion

Bicortical button fixation has gained popularity due to its high initial load to failure allowing an early range of motion and rehabilitation. The position of the button at the far side of the radial bone poses an inherent risk of posterior interosseous nerve injury and nonanatomical fixation. Several authors proposed an intramedullary fixation to alleviate the risk of PIN damage and allow the anatomical reinsertion via a single-incision approach. Load to

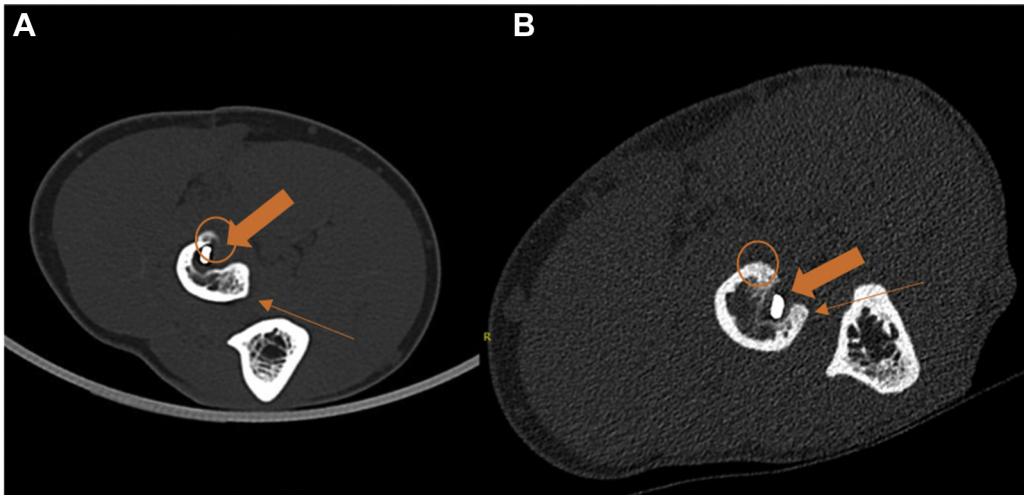

Figure 3 CT images at 6 months. (**A**) Nonanatomical repair with the drill hole through the fulcrum point of the radial tuberosity. (**B**) Anatomical repair with preservation of the fulcrum point. ⟶: orientation of the drill hole and site of tendon reinsertion. ⟶: Native tendon insertion site. ◯: Cam of the tuberosity acting as a fulcrum point.

failure and early outcomes of a nonanatomical reinsertion seem favorable. The purpose of the present study was to evaluate and report the short-term outcomes of an intramedullary anatomical refixation of the distal biceps tendon.

Functional outcomes at 2 weeks, 6 weeks, and 3 months in the present study were comparable to our experience with nonanatomical DBT refixation with the same intramedullary button.[9] The functional outcome at 6 months was excellent and comparable to the reported outcomes of other fixation methods.[2,7,10,11,13,24] Full pronation was regained later in the rehabilitation period compared to nonanatomical fixation.[9] We believe that this is a result of the anatomical reinsertion site. As the DBT rotates around the radial bone with pronation, the repaired tendon would stretch more with more ulnar (i.e. anatomical) reinsertion. Supination strength in maximal supination was comparable to the contralateral uninjured side and previous reported biomechanical outcomes of anatomical onlay reinsertion.[5] One patient had slightly less supination strength. However, we believe this was due to the concomitant shoulder operation on the same side. Although the site of the reinsertion of the tendon is not completely at the site of the native insertion, we believe that supination strength may be explained by the safeguarding of the radial edge of the tuberosity, which acts as a fulcrum.[21] (Fig. 2) Quick-DASH and MEPS outcome scores were excellent for all patients.

We noted a transient LACN neuropraxia in 36% of our cases. This minor complication is seen quite often in a limited anterior incision (reported range 7%-57%).[1,10] and typically resolves spontaneously, as it did in our patients. Heterotopic ossification is more often described in a double-incision technique than the single-incision technique.[15] We did observe a small heterotopic ossification in one patient. We believe this may be due to insufficient lavage at the end of the procedure. As the HO did not limit movement, it was treated expectantly. The removal of bone debris after drilling, extensive lavage, and hemostasis remains paramount to avoid heterotopic bone formation. PIN injury has been reported to be 0.3%.[1] Although rare, this complication may be disastrous. We observed no PIN injuries in this series. This is inherent to the intramedullary placed button. As the posterior cortex is not breached and no retractors are placed posterior to the radius, the risk of PIN injury is minimized. [4]

Radiographic evaluation showed no migration of the button during the postoperative period. We believe this to be an indication that, at the least, the button is connected to the tendon, whether by an intact repair or with the sutures. Gap formation is a well-described complication of anchor or onlay techniques.[20] The intraosseous position of the tendon described in this repair should minimize the risk of gap formation. CT evaluation showed no closure of the bone tunnel. (Fig. 3) Slight closure is to be expected as the bone repairs around the tendon. The present study showed no complete closure of the bone tunnel after 6 months. Soft tissue views of the CT images allow us to follow the tendon to the bone in all cases indicating that no gap formation was present.[19] A previous investigation in ACL surgery reported healing of the bone tunnel at 6 months.[18] We do not suspect further changes after this time.

There are several limitations to the present study. First, the study cohort was small. We chose a small cohort due to the novelty of this technique. Further investigation is needed to confirm these results on a larger scale. Second, supination strength was reported as a percentage compared to the uninjured contralateral side. We used this technique as it is the commonly reported method. Furthermore, we did not evaluate supination endurance. Finally, we only have a relatively short follow-up. As tunnel healing is reported to be complete at 6 months after surgery, and we saw no differences in functional outcomes between 3 months and 6 months we do not think longer follow-up will have a significant effect on the results presented.

Conclusion

Anatomical intramedullary fixation of the DBT has excellent functional outcomes at 6 months. The anatomical repair resulted in a restoration of supination strength. This technique allows the anatomical reinsertion of the distal biceps tendon while minimizing the risk of PIN injury. The intraosseous position of the tendon avoids gap formation. No adverse reactions of the button on the bone were seen.

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