Acta Orthop. Belg., 2020, **86**, 711-716

ORIGINAL STUDY

Accuracy and safety of the endoscopic repair of the distal biceps : a cadaveric study

Pieter CAEKEBEKE, Leesa GALATZ, Roger VAN RIET

From the ZOL Genk, Department of orthopedic surgery, Genk, Belgium

Clinical results of endoscopic distal biceps tendon repair have been shown to be comparable to open techniques in small series. This study evaluates safety and accuracy of the endoscopic technique. Sixteen fresh-frozen paired cadaveric upper extremities were used. The distal biceps tendons were cut and then repaired with the classic single incision bone button technique. Eight were done through an open technique, and eight were repaired endoscopically. Safety and accuracy were assessed by comparing the distance of the repair to neurovascular structures as well as the distance of the bone tunnel to the native biceps insertion. Paired t-tests were used to compare measurements. Significance level was set at p=0.05. There were no significant differences between the open and endoscopic groups, for any of the anatomic measurements. The ulnar artery was the closest neurovascular structure to the tunnel, with an average of 1 mm. The radial and recurrent radial arteries were located at 3 and 19 mm respectively. The median nerve was an average 10 mm from the tunnel, and both the SBRN and PIN at 12 mm. The distance between the PIN and the endobutton at the posterior side of the radius was an average 6 mm. There were no significant differences in variance between both groups related to the placement of the tunnel relative to the native biceps insertion. The single incision endoscopic-assisted technique of distal biceps repair can be performed consistently and with no added risk to neurovascular structures when compared to the classic open technique.

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.
Declaration of conflicting interests : all named authors hereby declare that they have no conflicts of interest to disclose.

Keywords : Elbow ; biceps ; endoscopy ; sports ; tendon ; anatomy ; safety

Level of evidence : IV

INTRODUCTION

Biceps tendon ruptures are relatively uncommon, with a reported prevalence of 1.2-2.5/100,000 per year *(1)*. The diagnosis of a complete rupture is usually made by clinical examination only. The hook test is usually positive[2], there is weakness with resisted supination and often pain and mild weakness to resisted flexion *(3,4)*. The biceps muscle may be retracted and the tendon stump can be palpated

■ Pieter Caekebeke[1], MD
■ Leesa Galatz[4]
■ Roger van Riet[2,3], MD, PhD
[1]*ZOL Genk, department of orthopedic surgery, Schiepse Bos 6, Genk, Belgium*
[2]*AZ Monica, department of orthopedic surgery, Stevenslei 20*
Deurne, Antwerp, Belgium
[3]*University Hospital Antwerp, department of orthopedic surgery, Wilrijkstraat 10, 2650 Edegem, Belgium*
[4]*Department of Orthopedic Surgery,Icahn School of Medicine, Mount Sinai Health System, New York, NY*
Correspondence : Pieter Caekebeke, ZOL Genk, Schiepse Bos 6, Genk, Belgium, +32-89-326118
Email : Pieter.caekebeke@zol.be
© 2020, Acta Orthopædica Belgica.

proximal to the elbow crease. The lacertus fibrosis is usually, but not always ruptured in these cases. Retraction of the muscle can be absent in patients where the lacertus remains intact. Radiographs, ultrasound and magnetic resonance scanning may aid the diagnosis, but don't always offer additional information.

Partial distal biceps tendon tears, tendonitis and bicipital bursitis are more difficult to diagnose by clinical examination only, and imaging modalities are usually needed in these patients. Even then, it may prove to be difficult to differentiate between these pathologies with a sensitivity of less than 60% with conventional MRI *(5)*. A simple debridement of the tendon by performing a bursectomy may suffice in patients with a tendonitis *(6)*, whereas a completion of the tear followed by a reinsertion may be indicated in patients with a more substantial partial tendon tear *(7,8)*. As the treatment differs, it is important to be able to differentiate within this spectrum of pathological conditions. However, even intra-operatively it is often difficult to estimate the percentage of tendon that is involved. Tears usually initiate from the radial side of the tendon *(9)* and are more commonly found on the distal insertion of the short head. This is the portion facing the tuberosity and in order to inspect this side of the tendon, it needs to be dissected and retracted *(8)*. This may potentially have a detrimental effect on the already weakened insertion or disturb a tendon that is essentially intact. Biceps endoscopy has been proposed in order to overcome this disadvantage *(6,10,11)*. It was first described by Sharma and Mackay who performed an endoscopically-assisted biceps tendon reinsertion in two patients with a full thickness tear *(11)*. The technique was later adapted to the technique most commonly used today *(6,10,12)*.

The goal of this study was to evaluate the safety and accuracy of the single incision endoscopic-assisted technique compared to the open technique. Cadaveric research has been done *(13,14)*, but the accuracy and safety of the endoscopic single incision technique has not been studied.

MATERIALS AND METHODS

Sixteen fresh-frozen paired cadaveric upper extremities were thawed to room temperature. These

Figure 1A. — Endoscopy was performed through a single anterior 2-cm incision.

Figure 1B. — Following blunt dissection the biceps tendon and bursa is visualized.

specimens were donated to the university anatomy program and we paired and blinded. There were no visual signs of elbow deformities or previous surgery. The arms were positioned supine on a table. A 2-cm incision was made centrally on the forearm, 3-cm distal to the elbow crease. Following a visualization of the lateral cutaneous nerve, blunt dissection was carried to the biceps tendon and the bicipital bursa (Figue 1A-B).

A 4.5 mm trocar was introduced into the bursa and advanced between the tendon and the bicipital tuberosity. The bicipital tuberosity is the first landmark and once the bone of the radius is identified, the scope is directed towards the tendon. The tendon was evaluated for any signs of pathology

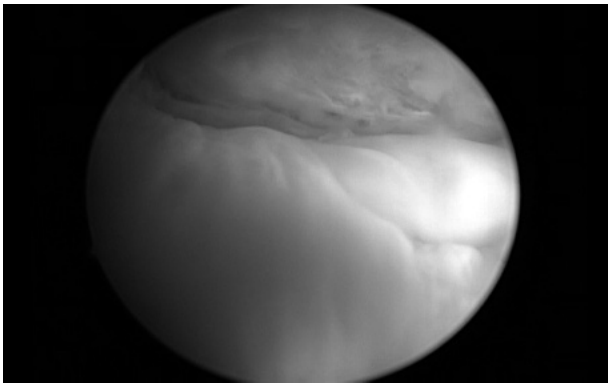

Figure 2. — Endoscopic view of the biceps tendon. The tendon is below on the figure and the radial tuberosity above.

and the proximal and distal limits of the bursa were identified (Figure 2).

The distal tendon was then cut under endoscopic visualization, delivered outside the incision, and sutured to a standard 4 by 12 mm cortical button (Smith&Nephew, London, UK) using no.2 Fiberwire (Arthrex, Naples, FL) suture. The repair was then performed in one of two ways, under direct 'open' or endoscopic view. Paired specimens were equally divided between open and endoscopic repair, in order to obviate any differences between groups. With the forearm fully supinated, retractors were placed medially and laterally with respect to the radius, protecting all soft tissues during instrumentation. A guidewire was drilled perpendicular to the surface of the bicipital tuberosity at the edge of the biceps footprint and a bicortical endobutton repair was performed. An 8 mm canulated drillbit was used to create a bone tunnel through the first cortex. A 4.5 mm cannulated drill was used to drill through the far cortex. The cortical button was then advanced through the bone tunnels and 'flipped'. Fluoroscopy was used to confirm the correct position of the button.

Anatomic dissection of specimen was then performed. The distance from the center of the tunnel to the following structures were measured with the arm in neutral rotation, the superficial branch of radial nerve (SBRN), the anterior portion of the posterior interosseous nerve (aPIN), the median nerve, the ulnar artery, radial and recurrent radial arteries, and their bifurcation (Figure 3).

Figure 3. — After insertion of the distal biceps the superficial branch of radial nerve (SBRN), the median nerve, the ulnar artery, radial and recurrent radial arteries, and their bifurcation were identified. Biceps reinsertion flagged with white arrow.

As the LACN was identified during blunt dissection, this entity was not included in the measurements. A handheld digital caliper with an accuracy of 0.1 mm was used for all measurements (SPI, digimax, USA). The shortest perpendicular distance was usind for measurements.

The posterior aspect of the radius was then carefully dissected in order to identify the posterior interosseous nerve (pPIN). The distance from the button and the PIN was measured with the forearm in supination, as this is the position in which the guidepin is drilled. All soft tissues were then removed, leaving only the radius and biceps tendon repair.

Length and width of the bicipital tuberosity were measured. The distance from the center of the native tendon stump to the edge of the tunnel was measured, as well as the distance of the center of the tuberosity and the center of the tunnel. Paired t-tests were used to compare measurements. Variance was calculated as a measure of reproducibility. Significance level was set at p=0.05.

RESULTS

The proximal to distal length of the tuberosity was an average of 21.0 mm (range 17.7 to 26.3, SD 2.5 mm) and the average width was 11.2 mm (range 9.1 to 13.2, SD 1.2 mm). There were no significant differences between specimens where an open versus an endoscopic procedure was performed (p=0.21).

The average distance from the center of the native biceps tendon insertion and the tunnel that was drilled under direct, 'open', view was 1.1 mm (range 0.0 to 4.5, SD 1.7 mm), compared to an average of 2.2 mm (range 0.0 to 9.3, SD 3.1 mm) for the endoscopic group. This difference was not significant (p=0.44) and there was no significant difference in variance (p=0.20) between both groups. The average distance from the center of the bicipital tuberosity and the center of tunnel that was drilled under direct, open visualization was 1.4 mm (range 0.0 to 3.6, SD 1.4 mm), compared to an average of 2.7 mm (range 0.0 to 9.0, SD 3.0 mm) for the endoscopic group. This difference was not significant (p=0.35) and there was no significant difference in variance (p=0.11) between both groups.

On the anterior side of the forearm, the ulnar artery was the closest neurovascular structure to the tunnel, with an average of 1.0 mm (range 0 to 6.1, SD 2.1mm). The radial artery and recurrent radial artery were located at an average distance of 3.1 mm (range 0 to 5.7, SD 2.5mm) and 18.7 mm (range 10.2 to 25.9, SD 4.9 mm) respectively, from the tunnel. The median nerve was an average of 10.2 mm (range 5.9 to 14.7, SD 2.6 mm) from the tunnel, and the SBRN and aPIN at 11.9 mm (range 8 to 15.6, SD 2.7 mm) and 12.0 mm (range 10.5 to 15.2, SD 1.4 mm) respectively (Table I).

The shortest distance between the pPIN and the endobutton at the posterior side of the radius was an average of 6.4 mm (range 1.3 to 12.0 mm, SD 3.6 mm), with the forearm in supination. When the arm was pronated, the button was in direct contact with the pPIN in 7 specimens. There were no significant differences between the open and endoscopic groups, for any of the anatomic measurements.

DISCUSSION

Endoscopic distal biceps tendon repair is an emerging technique, and can be done safely with respect to neurovascular structures *(6,10-12,15,16)*. The main potential advantage is the excellent visualization of the radial side of the tendon, without the need for pulling or retracting the injured tendon *(8)* or additional disruption of the blood supply of the tendon *(7)*. This portion of the tendon is the most commonly involved in partial biceps tendon ruptures and this portion may remain hidden from view in open techniques *(7,8)*. Although this procedure has been used clinically *(6,10,11,15,16)*, limited studies have evaluated its safety and none

Table 1. — Average distances between the vascular and neurological structures and the radial tunnel (mm)

		Median nerve	**Radial artery**	**Recurrent radial artery**	**ulnar artery**	**Sup branch Radial nerve**	**PIN ant**	**PIN post**
Open	Average	10,1	1,6	18,6	1,2	12,6	11,6	4,6
	Max	14,7	5,7	25,9	6,1	15,2	15,6	8,1
	Min	5,9	0,0	10,2	0,0	10,5	8,0	1,3
	SD	2,6	2,5	4,9	2,1	1,4	2,7	2,6
Endoscopic	Average	10,3	4,0	18,0	0,9	11,1	12,3	8,2
	Max	13,4	11,3	22,2	7,5	15,7	17,0	12,0
	Min	7,7	0,0	6,7	0,0	4,4	9,4	3,1
	SD	2,1	3,7	4,7	2,5	3,4	2,5	3,5

(Rec : Recurrent) [Avg : Average, Max : Maximum, Min : Minimum, SD : Standard Deviation].

have compared safety and accuracy to the classic single-incision open technique *(13,14)*.

Endoscopic biceps tendon repair was first described by Sharma and MacKay in 2005 *(11)*. They made a small incision proximal to the elbow crease and drilled a guide wire from proximal to distal, creating an oblique tunnel in the radius. Although no complications occurred in the two patients reported *(11)*, Saldua et al. showed that this oblique angle carried an increased risk to the PIN and recommended a different trajectory *(17)*. Bain et al. adapted the endoscopic technique and this is what we have been using clinically to date *(10)*.

Bhatia and colleagues showed that the 2-incision endoscopic technique is technically feasible in the treatment of distal biceps tendon ruptures *(13,14)*. They tested the technique with both suture anchors and cortical buttons. They also emphasize that the cortical button technique has a higher risk of iatrogenic injuries due to the position of the button. This technique differs however from our described technique as it is a 2-incison technique which requires an added proximal portal. We prefer a single incision to minimize possible other risks due to a second portal as we believe that biceps endoscopy is feasible through a single incision.

The aim of the current study was to determine, the feasibility and safety of an all-endoscopic distal biceps tendon repair. No significant differences with regards to the native insertion of the distal biceps tendon and the insertion of the reconstructed tendon were found when open and endoscopic techniques were compared. All tunnels were located within the native radial tuberosity. With respect to safety, comparison of the open and endoscopic techniques showed no significant differences with regards to the distance of neurovascular structures and the reconstructed biceps tendon or endobutton. Our results, like other studies, emphasize the importance of correct positioning of the arm in supination during endobutton insertion to protect the pPIN. When the forearm was pronated, all endobuttons contacted the nerve, so the endobutton must lie flush along the posterior cortex of the radius. The neurovascular structures were within mm of the tunnels and tendon, so it is imperative that retractors are placed on either side of the radius to provide direct visualization of the tendon stump and the radial tuberosity and to protect them during instrumentation.

One of the limitations is that this study was performed on cadaveric specimens. We are therefore unable to comment on possible neuropraxia or compression injuries to the nerves *(18)*. Secondly, the specimens were uninjured, so there was no scar or hematoma present. Therefore, these results may not be as easily applicable to the traumatic rupture, as they are to the partial tear or bursitis scenario.

CONCLUSION

In conclusion, our results show that the endoscopic technique can be performed consistently and with no added risk to neurovascular structures compared to the open technique. Due to the close proximity of the anterior neurovascular structures, we do recommend the use of retractors when shavers or drills are used.

REFERENCES

1. **Safran MR, Graham SM.** Distal biceps tendon ruptures : incidence, demographics, and the effect of smoking. *Clinical orthopaedics and related research*. 2002(404) : 275-83.
2. **O'Driscoll SW, Goncalves LB, Dietz P.** The hook test for distal biceps tendon avulsion. *The American journal of sports medicine*. 2007, 35(11) : 1865-9.
3. **Sarda P, Qaddori A, Nauschutz F, Boulton L, Nanda R, Bayliss N.** Distal biceps tendon rupture : current concepts. *Injury*. 2013, 44(4) : 417-20.
4. **Schmidt CC, Jarrett CD, Brown BT.** The distal biceps tendon. *The Journal of hand surgery*. 2013, 38(4) : 811-21, quiz 21.
5. **Festa A, Mulieri PJ, Newman JS, Spitz DJ, Leslie BM.** Effectiveness of magnetic resonance imaging in detecting partial and complete distal biceps tendon rupture. *The Journal of hand surgery*. 2010, 35(1) : 77-83.
6. **Bain GI, Johnson LJ, Turner PC.** Treatment of partial distal biceps tendon tears. *Sports Med Arthrosc*. 2008, 16(3) : 154-61.
7. **Dellaero DT, Mallon WJ.** Surgical treatment of partial biceps tendon ruptures at the elbow. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons* [et al.]. 2006, 15(2) : 215-7.
8. **Kelly EW, Steinmann S, O'Driscoll SW.** Surgical treatment of partial distal biceps tendon ruptures through a single posterior incision. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons* [et al]. 2003, 12(5) : 456-61.

9. **Davis WM, Yassine Z.** An etiological factor in tear of the distal tendon of the biceps brachii, report of two cases. *The Journal of bone and joint surgery American volume*. 1956, 38-A(6) : 1365-8.
10. **Eames MH, Bain GI.** Distal biceps tendon endoscopy and anterior elbow arthroscopy portal. *Tech. Shoulder Elbow Surg.* 2006(7) : 139-42.
11. **Sharma S, MacKay G.** Endoscopic repair of distal biceps tendon using an EndoButton. *Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association.* 2005, 21(7) : 897.
12. **Vandenberghe M, van Riet R.** Distal biceps ruptures : open and endoscopic techniques. *Curr. Rev. Musculoskelet Med.* 2016, 9(2) : 215-23.
13. **Bhatia DN, DasGupta B, Panjwani T.** Cadaveric study of anterior and posterior elbow endoscopy portals for endoscopic distal biceps repair : comparative anatomy-at-risk. *Surg. Radio. Anat*. 2016, 38(7) : 781-91.
14. **Bhatia DN, Kandhari V.** Analysis of technical feasibility and neurovascular safety of endoscopic distal biceps repair : a cadaveric study. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons* [et al.]. 2018, 27(11) : 2057-67.
15. **Duffiet P, Fontes D.** [Endoscopic repair of distal biceps brachii tendon avulsion : a new technique. Report of 25 cases]. *Chir. Main*. 2009, 28(3) : 146-52.
16. **Gregory T, Roure P, Fontes D.** Repair of distal biceps tendon rupture using a suture anchor : description of a new endoscopic procedure. *The American journal of sports medicine*. 2009, 37(3) : 506-11.
17. **Saldua N, Carney J, Dewing C, Thompson M.** The effect of drilling angle on posterior interosseous nerve safety during open and endoscopic anterior single-incision repair of the distal biceps tendon. *Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association.* 2008, 24(3) : 305-10.
18. **Cain RA, Nydick JA, Stein MI, Williams BD, Polikandriotis JA, Hess AV.** Complications following distal biceps repair. *The Journal of hand surgery.* 2012, 37(10) : 2112-7.