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Distal Biceps Brachii Rupture

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Background: Distal biceps tendon ruptures are rare injuries that predominantly affect active men between the fourth and sixth decades, with a higher incidence in weightlifters and bodybuilders. This study aimed to comprehensively review cases involving distal biceps tendon ruptures, focusing on sociodemographic factors (such as sex, age, occupation, and smoking status), injury mechanisms, postoperative outcomes, and recorded complications.

Methods: This retrospective review examines distal biceps injuries at Royal Berkshire Foundation Trust NHS Hospital from 2017 to 2023. Analyzed data encompasses demographic information, injury mechanisms, clinical findings, and complications. Outcomes were assessed using the range of movement and Elbow Oxford Score.

Results: The average age of 73 patients (72 men and 1 woman) was 45.6 ± 9.4 years, with 75.3% falling between 36 and 55 years. Manual workers represented 46.6%, and 9.6% reported comorbidities and 6.8% steroid use. Lifting heavy objects and sports injuries were the predominant causes, constituting 43.8% and 13.7%, respectively. Most injuries (91.8%) involved complete tears, and most underwent acute surgery within the initial 4 weeks (84.9%). The most common complications were heterotopic ossification (23.3%) and neurological injury (16.4%). Ongoing weakness and fatigue were reported by 6.8%. At final follow-up, 75.7% of patients demonstrated a range of movement comparable to the contralateral side. However, 13.7% had a limited pronation-supination arch with a mean loss of 20° ± 14°, 11% had an extension lag with a mean of 15° ± 7°, and 2.7% showed a 10° flexion loss compared to the contralateral side.

Conclusions: Distal biceps injuries are rare but lead to substantial functional loss without operative treatment. Surgical repair yields positive functional outcomes. Our study aligns with existing literature, emphasizing a predominance of middle-aged men and manual workers. It underscores the impact of corticosteroids and smoking, highlights surgical efficacy, and advocates for increased research in distal biceps injury prevention and treatment understanding.

Keywords: *Biceps brachii, Tendon injuries, Rupture, Tendon repair, Elbow joint*

The biceps brachii muscle typically has 2 heads: the short head originates from the coracoid process and the long head from the supraglenoid tubercle.[1] Supernumerary heads, found in 9%–22% of people, often stem from the humerus shaft.[2] Distal tendons attach at the radial tuberosity, with a bursa reducing friction. The dual insertion enhances elbow flexion and supination power.[3] Distal biceps tendon ruptures, accounting for about 3% of biceps injuries, predominantly affect active men between the fourth and sixth decades, and are more common in weightlifters and bodybuilders due to the larger biceps cross-sectional area.[4] Safran and Graham[5] reported an incidence of distal biceps injuries of 1.2 ruptures per 100,000 persons per year. They usually result from a sudden extension load on a flexed, supinated arm.[6] The etiology is multifactorial, involving mechanical, degenerative, and hypovascular factors. Hypovascularity between tendon zones and reduced cross-sectional area during pronation increase rupture risk.[7] While partial and musculotendinous junction tears

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have been reported, complete tendon avulsion is the most frequent.[8] Smoking and anabolic steroids are associated with tendon degeneration and a higher risk of rupture.[9]

Diagnosis primarily relies on clinical presentation, with patients often describing a "pop" sensation and sharp pain in the antecubital fossa, typically after eccentric arm loading or attempts to prevent a fall. Initial pain may subside, followed by lingering discomfort. Complete tears are marked by swelling, ecchymosis, and the "Popeye sign," while reduced motion, especially in elbow flexion and forearm supination, characterizes the condition.[6] Specific tests aid diagnosis, but partial tears may present subtler signs. Ultrasonography or magnetic resonance imaging (MRI) assists in differentiating various antecubital pathologies.[10] Ruptures are categorized as acute (within 4 weeks) or chronic, the latter classified by the integrity of the lacertus fibrosus, affecting surgical outcomes.[7]

Previously, conservative treatment was common for biceps injuries. Morrey et al.[11] revealed significant motion loss with nonoperative management, indicating a 40% decline in supination strength and 30% in flexion. Partial tears might begin conservatively, reserving surgery for unresponsive cases. Acute injuries benefit from anatomical reattachment to the bicipital tuberosity, especially in active individuals. Nonoperative care suits those unsuitable for surgery and with low functional demands.[12] Chronic ruptures require anatomical tendon reinsertion, utilizing autograft or allograft. Nonanatomic reconstruction to the brachialis muscle is discouraged due to supination strength loss, which is crucial for patients with high functional demand.[13] This study aimed to comprehensively review distal biceps tendon rupture cases, focusing on sociodemographic factors, injury mechanisms, postoperative outcomes, and recorded complications.

METHODS

The requirements for approval of the Institutional Review Board and informed consent were waived due to the retrospective nature of this study. The study's methodology involved a retrospective review at Royal Berkshire Foundation Trust NHS Hospital in Reading, United Kingdom. Data extraction utilized Electronic Patient Records to gather information on patients presenting with distal biceps rupture between 2017 and 2022. Collected patient data included demographic information (such as sex, age, occupation, and smoking status), injury mechanisms, clinical findings, and documented complications. Elbow x-ray follow-ups at 6 and 12 weeks were conducted to assess the position of the biceps Endobutton and to evaluate for heterotopic ossification. The primary outcome measures included postoperative range of motion (ROM) and the Elbow Oxford Score. Ruptures were categorized as acute (presentation within 4 weeks) or chronic (presentation after 4 weeks).[14] Complete ruptures involved both distal biceps heads, while partial ruptures indicated continuity in some fibers.

RESULTS

This review included 73 patients over 6 years (2017–2023), with a mean age of 45.6 ± 9.4 years, ranging from 26 to 67 years. Only 1 woman experienced a distal biceps injury. The right side was affected in 53.4% of cases. Notably, 1

Table 1. Descriptive Analysis of Patients (N = 73)

Variable	No. (%)
Sex	
Male	72 (98.6)
Female	1 (1.4)
Dexterity	
Right	39 (53.4)
Left	34 (46.6)
Dominant hand	
Dominant	37 (50.7)
Non-dominant	36 (49.3)
Age	
Young adults (18–35 yr)	8 (11.0)
Middle-aged adults (36–55 yr)	55 (75.3)
Older adults (≥ 56 yr)	10 (13.7)
Occupation	
Manual workers	34 (46.6)
Office workers	28 (38.4)
Athletes	2 (2.7)
Miscellaneous	9 (12.3)
Comorbidity	7 (9.6)
Corticosteroid use	5 (6.8)
Smoking	
Yes	18 (24.7)
No	46 (63.0)
Ex-smoker	9 (12.3)

patient sustained bilateral injuries at different times due to a sports-related incident while lifting heavy weights at the gym. There was no significant difference observed between injuries on dominant and non-dominant limbs. The majority of affected individuals were middle-aged adults, comprising 75.3% of cases. Approximately 11% of injuries occurred in adults under 35 years old, while 13.7% affected those over 65 years old. Manual workers comprised 46.6% of the patients, with office workers accounting for 38.4%. Nonsmokers constituted 63% of the patients, with smokers and ex-smokers making up the remaining 37% (Table 1). Comorbidities were present in 7 patients (9.6%), including conditions such as diabetes, systemic lupus erythematosus, gout, and obesity, known to impact tendons and potentially contribute to tendinopathy. Additionally, 5 patients (6.8%) reported using corticosteroids, including anabolic steroids.

The mechanisms of distal biceps rupture were as follows: lifting heavy objects accounted for 43.8%, followed by sports injuries, which accounted for 13.7%. In 9.6% of cases, the mechanism was not identified (Table 2). During the preoperative clinical examination, the Hook test yielded a positive result in nearly three-quarters of patients and a negative result in one-fourth. The tear grade was determined through imaging studies such as ultrasound or MRI, or based on intraoperative findings. The majority of injuries (91.8%) were identified as complete tears, while the remaining 8.2% were identified as partial tears, with some fibers of the distal biceps tendon—either from the short head or long head—still attached to the radial tuberosity. The mean duration between the injury and the surgical intervention is approximately 3 weeks (20.5 ± 20.2 days), with a range spanning from 3 days to 119 days. Nine patients underwent surgery within the initial week, 25 patients during the second week, 14 patients in the third week, 4 patients in the fourth week, and 11 patients after the fourth week. Only 38.4% of tendons were retrieved using a single wound over the antecubital fossa, and 61.6% required another wound over the retracted biceps on the distal arm to retrieve the tendon.

On final follow-up, most patients (75.7%) demonstrated a comparable range of movement to the contralateral side. However, 10 patients (13.7%) had limited pronation–supination arch with a mean loss of 20° ± 14°. Eight patients (11%) had extension lag with a mean of 15° ± 7°, and 2 patients (2.7%) showed 10° flexion loss compared to the contralateral side. All patients' mean Oxford Shoulder Score was 46.4 ± 2.1 out of 48.

Table 3 illustrates postoperative complications following repair: 16.4% experienced sensory neurological injury (10 lateral antebrachial cutaneous and 2 superficial radial nerve injuries), mostly neuropraxia, resolving within 3–6 months. No motor injuries were reported. Heterotopic ossification occurred in 23.3% (Brooker grade 1, indicating islands of bone within soft tissues), a radiological

Table 2. Descriptive Analysis of Clinical Presentation (N = 73)

Variable	No. (%)
Mechanism of injury	
Lifting heavy object	32 (43.8)
Pulling heavy object	9 (12.3)
Pushing heavy object	5 (6.9)
Sport injury	10 (13.7)
Falling down	3 (4.1)
Hyperextension elbow injury	7 (9.6)
Others	7 (9.6)
Hook test	
Positive	53 (72.6)
Negative	20 (27.4)
Grade of tear	
Partial tear	6 (8.2)
Complete tear	67 (91.8)
The interval from injury to surgery	
Acute (≤ 4 wk)	62 (84.9)
Chronic (> 4 wk)	11 (15.1)
Incision*	
Single forearm incision	28 (38.4)
Dual volar incision	45 (61.6)

*Dual incision refers to a second incision over the distal arm, utilized for retrieving the retracted tendon.

Table 3. Postoperative Complications

Variable	No. (%)
Neurological injury	12 (16.4)
Heterotopic ossification	17 (23.3)
Vascular injury	1 (1.4)
Re-rupture	2 (2.7)
Infection	1 (1.4)
Weakness and fatigability	5 (6.8)

finding with no clinical significance. One patient required ligation and division of the recurrent leash of Henry due to intraoperative bleeding. Two patients (2.7%) suffered re-ruptures: 1 due to a postoperative fall repaired after 4 days, and the other linked to cramping, requiring reoperation 1 week after re-rupture. One patient had a superficial infection treated with oral antibiotics. Upon final discharge, 6.8% reported weakness and fatigability compared to the contralateral limb; however, this was a subjective perception without objective findings.

DISCUSSION

In this study, we conducted a review of 73 patients who underwent surgery for distal biceps rupture, examining sociodemographic factors, injury mechanisms, postoperative outcomes, and recorded complications. The distribution of injuries in our study aligned with existing literature, with the majority being men, and three-quarters of patients falling between 35 and 55 years old. While some literature reports a higher frequency in the dominant hand, we did not observe differences between dominant and non-dominant limbs or right and left dexterity.

The deleterious effects of steroids on tendons have been extensively studied. Animal models demonstrate decreased tensile force, biomechanical interference, reduced durability, and an increased risk of inflammation and necrosis. Steroids disrupt tendon organization at histological and cellular levels, potentially diminishing mechanical properties.[15] Conflicting opinions exist, with some studies suggesting temporary and self-limited adverse effects due to methodological variations.[16]

The relationship between anabolic androgenic steroids (AAS) and tendon injuries remains unclear. While some studies link AAS use to increased tendon stiffness, there is insufficient data to unequivocally support this link, especially in distinguishing between decreased elasticity and actual tendon rupture. Two commonly proposed hypotheses explain AAS-related tendon ruptures. The first suggests that AAS primarily causes muscular hypertrophy without corresponding strengthening of attached tendons, leading to ruptures. The second proposes that high AAS doses, particularly when combined with physical activity, can directly damage tendon structure, making them prone to rupture even without excessive stress. However, the available evidence does not definitively support or dismiss either theory.[17]

Smoking is thought to enhance neovascularization through hypoxia and microvascular perfusion impairment. However, a study by Zabrzynski et al.[18] conducted an immunohistochemical study on the long head of the biceps, revealing a negative correlation between smoking and neovascularization. This implies smoking results in a hypovascular tendon area and subsequent tendon degeneration. While these findings focus on the LHB, their implications extend to the distal biceps and all tendons.

Due to the limited description of the mechanism of injury, we classified them into broad categories, such as lifting and pulling heavy objects. Both categories describe excessive eccentric tension as the arm being forced from a flexed to an extended position. Sport and hyperextension injuries may represent the same previous mechanism. However, we are unsure how pushing heavy objects can contribute to such injuries. Similarly, falling can load the biceps tendon and lead to rupture. A complete tendon injury involves both the long and short heads of the distal biceps, whereas partial injury suggests the engagement of either head. These partial tears are further categorized into traumatic and atraumatic ruptures. Traumatic ruptures predominantly affect the short head, while atraumatic injuries primarily involve the long head.[19] Unfortunately, our cohort lacks documentation specifying the head involved in these cases.

Ultrasound is a valuable diagnostic tool for confirming distal biceps rupture swiftly and easily at the clinic, aligning with clinical presentation. However, challenges, especially with partial tears, arise due to anisotropy and restricted visualization at the tendon's radial tuberosity insertion owing to its oblique course.[20] In cases of partial injuries, MRI emerges as a more informative diagnostic method.[21] The analysis conducted by Cuzzolin et al.[22] systematically reviewed operative versus nonoperative management for distal biceps tendon lesions. This comprehensive review involved 53 studies comprising 1,380 patients to compare both approaches. Surgical methods showed notable advantages over nonoperative methods, evident in various scores, such as Disabilities of the Arm, Shoulder and Hand scores, Mayo Elbow Performance Index, flexion strength (94.7% vs. 83.0%), and supination strength (89.2% vs. 62.6%). However, surgical methods had their share of complications, including issues like heterotopic ossifications, transient sensory and motor nerve injuries, and persistent motorial disorders. While different surgical techniques demonstrated similar outcomes regarding fixation methods, the single-incision approach displayed improved pronation ROM compared to the double-incision method. Overall, surgical management outperformed nonoperative approaches, yielding superior strength and patient-reported outcomes, with slight variations in ROM across different surgical techniques.

Various surgical techniques have been described for

repairing distal biceps tendon avulsions, utilizing double-incision or single-incision methods with different fixation approaches such as suture anchors, intra-osseous screws, or cortical buttons. Single or dual incisions typically involve either the anterior single-incision technique or a combined approach with a smaller anterior incision over the antecubital fossa and a second posterolateral elbow incision. In our review, all cases utilized an anterior single incision; any mention of a double incision pertains to a second incision over the distal arm, employed for retrieving the retracted tendon.

Biomechanical strength, outcomes, and complication rates among different techniques were compared in multiple studies. We published a single-center study[23] evaluating the outcomes of repairing distal biceps avulsion using the endo-button technique. Conducting 45 repairs on 43 patients with an average follow-up period of 3.2 years, the results indicated good short-term outcomes, minimal complications, elevated patient satisfaction, and positive functional results following distal biceps tendon repair.

The late repair of chronic distal biceps ruptures presents challenges and typically yields less favorable and more unpredictable outcomes compared to acute repairs. Surgical strategies for chronic cases include attempts to mobilize the biceps for an anatomic repair, performing a nonanatomic repair (transfer) to the brachialis muscle, or opting for distal biceps tendon reconstruction. While techniques like biceps mobilization and tenodesis demonstrate some effectiveness, they often come with limitations.[24] Late reconstruction alternatives involve autografts such as fascia lata, semitendinosus, and flexor carpi radialis, or utilizing an Achilles tendon allograft.[25] Despite its demanding nature, the preferred method involves employing an Achilles tendon allograft through a single anterior approach, though it is more suitable for high-functioning individuals, particularly athletes.[26]

Complications following surgical repair vary based on the employed technique, whether single or double incisions were used. Neurological complications encompass the lateral antebrachial cutaneous nerve, superficial radial nerve, and the more severe posterior interosseous nerve palsy. Dunphy et al.[27] analyzed 784 distal biceps tendon repairs, comparing double-incision and single-incision techniques. The double-incision method with bone tunnel–suture fixation exhibited higher rates of posterior interosseous nerve palsy (3.4%), heterotopic bone formation (7.6%), and reoperation (8.3%) compared to the single-incision technique. Conversely, the single-incision technique had a higher incidence of lateral antebrachial cutaneous nerve palsy (24.4%) compared to the double-incision technique (4.1%).[28] In our study, we reported 16.4% of neurological injuries involving the lateral antebrachial cutaneous nerve and superficial radial nerve, with no injuries involving the posterior interosseous nerve. However, most of these findings were neuropraxia, resolving during follow-up and at discharge.

Heterotopic ossification may be asymptomatic and detected solely through radiographic examination. Alternatively, it can present as a palpable lump, causing pain, nerve irritation, and mobility issues. In severe cases, it may progress to radioulnar synostosis, with reported incidences ranging from 4% to 36%.[29] While not all surgeons routinely conduct postoperative radiographic assessments, our practice includes standard evaluations at 6 weeks, occasionally repeated at 3 months. In our study, around 23.3% of patients displayed Brooker grade 1 heterotopic ossification, which exhibited no symptoms and did not necessitate intervention.

Our study has some limitations, including its retrospective design and insufficient documentation of the exact mechanism, comorbidities, and the use of steroids and androgens. These factors preclude a detailed analysis of their frequencies. Our findings were consistent with previous research, namely that the majority of cases occurred in men between the ages of 35 and 55 years. Notable findings include the prevalence of injuries in manual workers, the potential consequences of corticosteroid use, and the complex relationship between smoking and tendon neovascularization. The study emphasizes the efficacy of surgical intervention, with various surgical techniques showing favorable results in terms of strength and patient-reported measures. Complications such as sensory neurological injury, heterotopic ossification, and re-ruptures, on the other hand, necessitate careful clinical management. More research and prospective studies are needed to improve our understanding of distal biceps injury prevention and therapeutic approaches.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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REFERENCES

1. Hutchinson HL, Gloystein D, Gillespie M. Distal biceps tendon insertion: an anatomic study. J Shoulder Elbow Surg. 2008;17(2):342-6.
2. Benes M, Kachlik D, Lev D, Kunc V. Accessory heads of the biceps brachii muscle: a systematic review and meta-analysis. J Anat. 2022;241(2):461-77.
3. Eames MH, Bain GI, Fogg QA, van Riet RP. Distal biceps tendon anatomy: a cadaveric study. J Bone Joint Surg Am. 2007;89(5):1044-9.
4. Kelly MP, Perkinson SG, Ablove RH, Tueting JL. Distal biceps tendon ruptures: an epidemiological analysis using a large population database. Am J Sports Med. 2015;43(8):2012-7.
5. Safran MR, Graham SM. Distal biceps tendon ruptures: incidence, demographics, and the effect of smoking. Clin Orthop Relat Res. 2002;(404):275-83.
6. Lappen S, Siebenlist S, Kadantsev P, et al. Distal biceps tendon ruptures occur with the almost extended elbow and supinated forearm: an online video analytic study. BMC Musculoskelet Disord. 2022;23(1):599.
7. Ramsey ML. Distal biceps tendon injuries: diagnosis and management. J Am Acad Orthop Surg. 1999;7:199-207.
8. Jaschke M, Rekawek K, Sokolowski S, Kolodziej L. Distal biceps tendon rupture: a comprehensive overview. EFORT Open Rev. 2023;8(11):865-73.
9. Schamblin ML, Safran MR. Injury of the distal biceps at the musculotendinous junction. J Shoulder Elbow Surg. 2007;16(2):208-12.
10. Al-Ani Z, Lauder J. Ultrasound assessment in distal biceps tendon injuries: techniques, pearls and pitfalls. Clin Imaging. 2021;75:46-54.
11. Morrey BF, Askew LJ, An KN, Dobyns JH. Rupture of the distal tendon of the biceps brachii: a biomechanical study. J Bone Joint Surg Am. 1985;67(3):418-21.
12. Baker BE, Bierwagen D. Rupture of the distal tendon of the biceps brachii: operative versus non-operative treatment. J Bone Joint Surg Am. 1985;67(3):414-7.
13. Bajwa A, Simon MJ, Leith JM, Moola FO, Goetz TJ, Lodhia P. Surgical results of chronic distal biceps ruptures: a systematic review. Orthop J Sports Med. 2022;10(1):23259671211065772.
14. Luokkala T, Siddharthan SK, Karjalainen TV, Watts AC. Distal biceps hook test: sensitivity in acute and chronic tears and ability to predict the need for graft reconstruction. Shoulder Elbow. 2020;12(4):294-8.
15. Dean BJ, Lostis E, Oakley T, Rombach I, Morrey ME, Carr AJ. The risks and benefits of glucocorticoid treatment for tendinopathy: a systematic review of the effects of local glucocorticoid on tendon. Semin Arthritis Rheum. 2014;43(4):570-6.
16. Dinhane KG, Godoy-Santos AL, Fabro AT, Moretto MR, Depra I, Yoshida WB. Short-term changes after corticosteroid injections into the normal tendons of rabbits: a controlled randomized study. Am J Sports Med. 2019;47(3):721-8.
17. Jones IA, Togashi R, Hatch GF, Weber AE, Vangsness CT. Anabolic steroids and tendons: a review of their mechanical, structural, and biologic effects. J Orthop Res. 2018;36(11):2830-41.
18. Zabrzynski J, Gagat M, Paczesny L, Grzanka D, Huri G. Correlation between smoking and neovascularization in biceps tendinopathy: a functional preoperative and immunohistochemical study. Ther Adv Chronic Dis. 2020;11:2040622320956418.
19. Nicolay RW, Lawton CD, Selley RS, et al. Partial rupture of the distal biceps brachii tendon: a magnetic resonance imaging analysis. J Shoulder Elbow Surg. 2020;29(9):1859-68.
20. Kalume Brigido M, De Maeseneer M, Jacobson JA, Jamadar DA, Morag Y, Marcelis S. Improved visualization of the radial insertion of the biceps tendon at ultrasound with a lateral approach. Eur Radiol. 2009;19(7):1817-21.
21. Greif DN, Huntley SH, Alidina S, et al. MRI findings of chronic distal tendon biceps reconstruction and associated post-operative findings. Skeletal Radiol. 2021;50(6):1095-109.
22. Cuzzolin M, Secco D, Guerra E, Altamura SA, Filardo G, Candrian C. Operative versus nonoperative management for distal biceps brachii tendon lesions: a systematic review and meta-analysis. Orthop J Sports Med. 2021;9(10):23259671211037311.
23. Butler K, Almigdad A, Kim J, Dodson E, Malhas A. Outcomes of distal biceps repair at two-year follow-up. Eur J Orthop Surg Traumatol. 2024;34(2):989-93.
24. Darlis NA, Sotereanos DG. Distal biceps tendon reconstruction in chronic ruptures. J Shoulder Elbow Surg. 2006;15(5):614-9.
25. Kaplan FT, Rokito AS, Birdzell MG, Zuckerman JD. Reconstruction of chronic distal biceps tendon rupture with use of fascia lata combined with a ligament augmentation device: a report of 3 cases. J Shoulder Elbow Surg. 2002;11(6):633-6.
26. Sanchez-Sotelo J, Morrey BF, Adams RA, O'Driscoll SW. Reconstruction of chronic ruptures of the distal biceps tendon with use of an Achilles tendon allograft. J Bone Joint Surg Am. 2002;84(6):999-1005.
27. Dunphy TR, Hudson J, Batech M, Acevedo DC, Mirzayan R. Surgical treatment of distal biceps tendon ruptures: an analysis of complications in 784 surgical repairs. Am J Sports Med. 2017;45(13):3020-9.

28. Amarasooriya M, Bain GI, Roper T, Bryant K, Iqbal K, Phadnis J. Complications after distal biceps tendon repair: a systematic review. Am J Sports Med. 2020;48(12):3103-11.

29. Casavant AM, Hastings H. Heterotopic ossification about the elbow: a therapist's guide to evaluation and management. J Hand Ther. 2006;19(2):255-66.