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Efficacy of the "Salento technique", a modified two-incision approach in distal biceps brachii tendon repair. Surgical description and outcomes analysis

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ABSTRACT

Introduction: The biceps brachii lesion needs to be treated surgically. A modified two incisions technique is proposed and reviewed. Material and Methods: All patients were treated with the same technique. The outcomes were measured with the Quick-DASH Score (QDS), and the Mayo Elbow Performance Score (MEPS). Postoperative complications and distal biceps tendon strength were registered also.
Results: At one year from the trauma, the QDS and the MEPS were excellent in all patients. 72.97% fully recovered and returned to work after 6 months from the trauma.
Discussion: This technique, thanks to its preservation of anatomical structures, provides great outcomes.

1. Introduction

The distal biceps tendon rupture represents only 3% of all biceps injury,[1] with an annual incidence of 0.9–1.8 per 100,000 patients.[2] The injury usually happens when a flexed and supinated arm is suddenly overloaded during an eccentric contraction of the biceps. The majority of patients are middle-aged men and the dominant arm is the most affected.[3]

In most cases, both the short and the long heads of the tendon were detached from their insertion at the radial tuberosity, 24° from the apex.[3] This lesion has to be treated surgically in young patients because a conservative treatment would result in an average 30% loss in flexion strength and an average 50% loss in supination strength.[4] Non-operative treatment could be considered, provided that the patient understands the potential for residual weakness, particularly in forearm supination. Acute tears are best treated by primary repair with good clinical outcomes using either single-incision or double-incision techniques. Single-incision techniques may carry a higher risk of nerve-related complications, whereas double-incision techniques have historically been considered to carry a higher risk of heterotopic ossification, particularly if the ulna is exposed. Various fixation techniques, including bone tunnels, cortical buttons, suture anchors, interference screws or a combination of them, seem to provide different fixation strength but similar clinical outcomes.[5]

In this retrospective study, we reported our ultra-decennial experience in managing biceps tendon tears, with a modified double incision technique, derived from the Morrey modified two-incision approach[6] that maximizes the care of the anatomy and that we named the "Salento Technique" in honour of the beautiful

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geographic region, at the southern end of the administrative region of Apulia in Southern Italy, where the technique had its origin.

2. Materials and methods

From January 2000 to April 2017, 68 patients were treated surgically for rupture of the distal biceps brachii tendon.

Inclusion criteria were: acute injury, age between 18 and 65 years old, surgical treatment within 15 days from the trauma, male or female, workers or not, the minimum follow up time period for inclusion was 6 months.

Exclusion criteria were: previous elbow or upper limb injuries, haematological or oncological pathologies, metabolic diseases, chronic tendinopathy investigated asking the patients if they had suffered from previous pain in the elbow, other surgical treatment than the Salento Technique, incomplete tendon rupture, patients over 65 years old and professional athletes. We excluded the athletes not to bias the results, due to their higher motivation to heal and their more intensive rehabilitation settings than common people.

The population of our study was reduced to 37 patient by study criteria.

The mean age was 34.3 (range 24–65); all patients were males. All ruptures were complete according to Morrey's Classification,[7] and the side affected was always the dominant one. (Table 1).

All the patients started the prophylaxis against heterotopic ossification on the day of surgery, but it was changed during the study period. The first 16 patients, operated before 2010, received 75 mg of sustained-release indomethacin 1 time daily for 4 weeks. The other 21 patients, from 2010, received Celecoxib 200 mg 2 times daily for 3 weeks.

The chosen criteria to evaluate the injured side (IS) compared to not injured side (NIS) during the clinical follow-up were: the subjective quality of life and the elbow function measured by Quick-DASH Score (QDS),[8] the objective function and the quality of life measured by the Mayo Elbow Performance Score (MEPS)[9] and postoperative complications. The clinical follow-up was performed weekly until the twelfth week, to assess the functional improvement with physiotherapy and until when the hinge brace was removed, then was done at 6 months and at 12 months after the surgery. The QDS and MEPS were measured before the trauma (T0); at the time of trauma (T1); at 4 weeks (T2); at 6 weeks (T3); at 8 weeks (T4); at 12 weeks (T5); at 26 weeks (T6); at 52 weeks (T7) from the trauma. To assess flexion and supination forces and distal biceps tendon strength, a hydraulic dynamometer was used only at T6 and T7. Five measurements were taken each time, always by the same evaluator, and the mean of the last four was calculated. The first measurement was disregarded to avoid bias caused by the patient's awareness of the measurement process.

All patients gave their informed consent and were treated according to the ethical standards of the Helsinki Declaration.

Table 1
Description of the population, demographic data and risk factors. *Tertiary Sector: it involves the provision of services to other businesses. Services may involve the transport, distribution and sale of goods from producer to a consumer, as may happen in wholesaling and retailing, pest control or entertainment.

Number of patients	37
Mean age in years (range)	34.3 (24–65)
Gender (M:F)	All Male
Side of Distal Tendon Biceps Rupture, N (%)	Right: 25 (67.57%) Left: 12 (32.43%)
Working Activity, N (%)	Agricultural: 15 (40.54%) Industrial: 14 (37.84%) Tertiary Sector*: 8 (21.62%)
Injury settings, N (%)	Work: 22 (59.46%) Sport: 10 (27.03%) Hobby: 5 (13.51%)
Smoking Habit, N (%)	Yes: 12 (32.43%) >20 cig/d: 6 (16.21%)
Alcohol Habit, N (%)	Occasional: 10 (27.03%) Frequent: 24 (64.86%) Abuse: 3 (8.11%)

3. Description of the "Salento Technique"

All patients underwent the same surgical method: a double incision technique that uses a transverse incision in the antecubital fossa and a second incision on the dorsal margin of the radius. During surgical dissection, the radial recurrent artery is identified but never ligated. While dissecting on the volar aspect, pay constant attention to place the forearm in full supination, because it brings the radial nerve far from the midline decreasing the risk of its injury. During the procedure, the lateral antebrachial cutaneous nerve, the posterior interosseous nerve and superficial radial nerves are also encountered and protected. After identification of the distal portion of the biceps tendon, the degenerated part is resected and two locking Krackow sutures with n.3 Ethibond™ (Johnson & Johnson, New Brunswick, NJ, USA) are passed through the distal part of the tendon (Fig. 1A). Then the bicipital tuberosity is identified and a curved clamp, inserted volar to dorsal, is lead through the interosseous membrane to identificate the exact site where the second longitudinal incision is made. To reduce the risk of radio-ulnar synostosis, this action has to be done only once, avoiding to repeat the drilling of the membrane. With the forearm in maximal pronation, the tuberosity is exposed with a muscle-splitting technique between the supinator and the extensor digitorum communis.[10] Three drill holes are placed approximately at 1 cm intervals through the dorsal cortical margin of the tuberosity (Fig. 1B and C), directed anteriorly, where there is the insertion of the injured tendon. The tendon sutures are then passed through the holes with a plastic trocar for anterior cruciate ligament (Fig. 1D), which is then removed. With the elbow at 90° of flexion and the forearm pronated, the biceps tendon is pulled into the tunnel made in the tuberosity to receive its bulbous end and the sutures are pulled tight and tied (Fig. 2A-B-C), after checking the right tendon tension (Fig. 2D).

4. Rehabilitation protocol

We created a specific rehabilitation protocol to provide the clinicians and the physiotherapists with precise indications on the postoperative course of rehabilitation, and to rationalize and to have the entire patient population conform to a single program in order to reduce the bias (Appendix A).

5. Statistical analysis

Descriptive statistic was used to summarize the characteristics of the study group and subgroups, including means and standard deviations of all continuous variables. The *t*-test was used to compare continuous outcomes and to estimate the amount of the change, the statistical threshold is set at $p < 0.05$.

6. Results

The surgery was performed on average in 3.6 days (range 1–7) after the trauma and lasted an average of 42.2 min (range 33–75). There wasn't any blood transfusion.

All the patients completed the last follow-up. Table 2 summarizes the results.

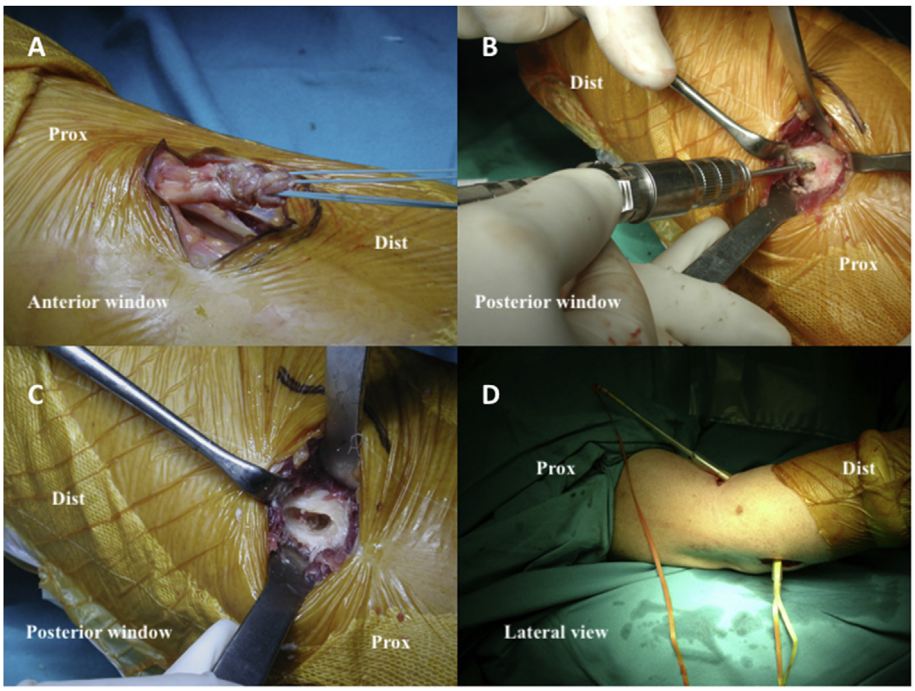

Fig. 1. Surgical Technique. (A) anterior skin incision with identification of distal biceps tendon and two locking Krakow sutures; (B–C) the second posterior window allows to drill and to prepare the tuberosity; (D) the sutures are pulled out from the first window to the second window using a plastic trocar. Prox: proximal; Dist: distal.

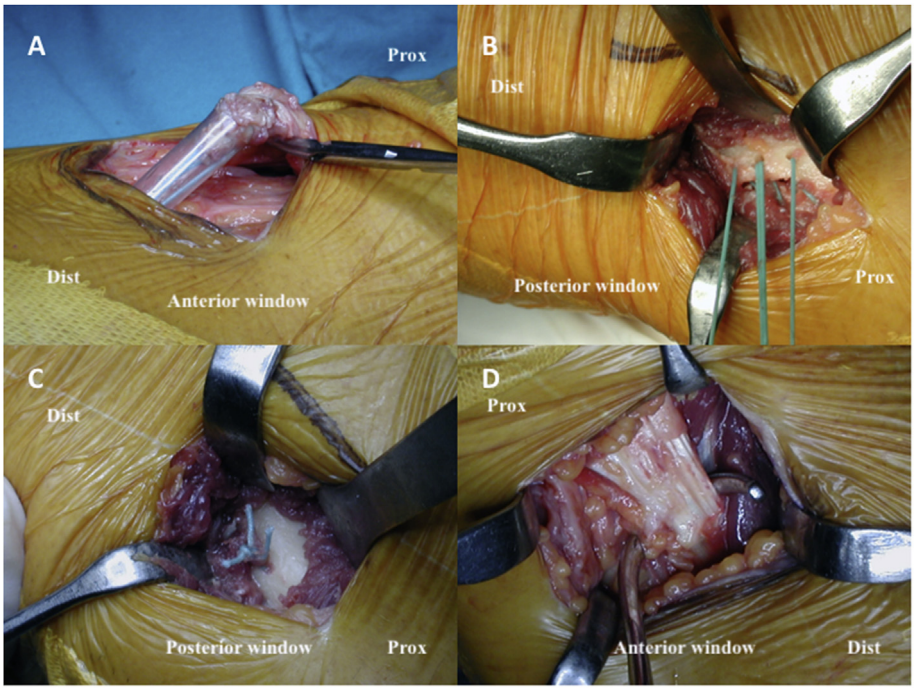

Fig. 2. Surgical Technique. (A) anterior window, the tendon protected by the plastic trocar; (B–C) posterior window, the sutures are prepared and tightened; (D) anterior window, the tendon tension is checked. Prox: proximal; Dist: distal.

At the time of trauma (T1), both the QDS and the MEPS was obviously lower for IS than NIS ($p < 0.05$). The difference remained statistically significant ($p < 0.05$) until the 12 weeks follow-up (T5), then lacks significativity, and the scores tend to merge; details in Table 2 and Fig. 3.

At 26 weeks from the trauma (T6), the difference in the mean flexion and supination force between the two sides, was still statistically significant, and lose significativity at the 52 weeks follow-up (T7), when the IS mean flexion and supination force reaches 24.6 N and 4.2 N, corresponding respectively to 96.32% and to 98.76% of that in NIS group.

At the last follow-up the mean IS flexion was 132.8° (range 119–135°), corresponding to 97.6% of that of the NIS, and the mean extension was of 1.81° (range 1–7.5°) of flexion. Nobody reached

Table 2
Comparison of the subjective and objective quality of life, the force and the range of motion, between the injured side (IS) and the not injured side (NIS) before the trauma (T0), at the time of trauma (T1), at 26 weeks (T6) and at 52 weeks (T7) from the trauma.

		IS	NIS	P Value
The subjective functionality of the elbow and quality of life measured by QDS in points (range)	T0	96.8 (95–100)	96.8 (95–100)	$p > 0.05$
	T1	48.9 (38.8–66.2)	96.8 (95–100)	**$p < 0.05$**
	T6	92.4 (92.3–100)	96.8 (95–100)	$p > 0.05$
	T7	93.2 (92.3–100)	96.8 (95–100)	$p > 0.05$
The objective function of the elbow and quality of life measured by MEPS in points (range)	T0	93.5 (90–100)	93.5 (90–100)	$p > 0.05$
	T1	45.3 (40–50)	93.5 (90–100)	**$p < 0.05$**
	T6	91.6 (85–100)	93.5 (90–100)	$p > 0.05$
	T7	91.6 (85–100)	93.5 (90–100)	$p > 0.05$
The mean flexion force was calculated in Newton (N) and (%) of force related to NIS	T6	22.6 N (83.75%)	26.3 N (100%)	**$p < 0.05$**
	T7	24.6 N (96.32%)	26.3 N (100%)	$p > 0.05$
The mean supination force was calculated in Newton (N) and (%) of force related to NIS	T6	3.5 N (82.31%)	4.2 N (100%)	**$P < 0.05$**
	T7	4.2 N (98.76%)	4.3 N (100%)	$p > 0.05$
The mean elbows range of motion in grade, (range) and (%) related to NIS	T7	Flexion: 132.8° (range 119–135°; 97.6%)	Flexion: 136° (range 122–135°; 100%)	$p > 0.05$
		Supination: 88.3° (range 81–90°; 98.3%)	Supination: 89.8° (range 82–90°; 100%)	$p > 0.05$
		Pronation: 82.7° (range 76–90°; 94.8%)	Pronation: 87° (range 80–90°; 100%)	$p > 0.05$

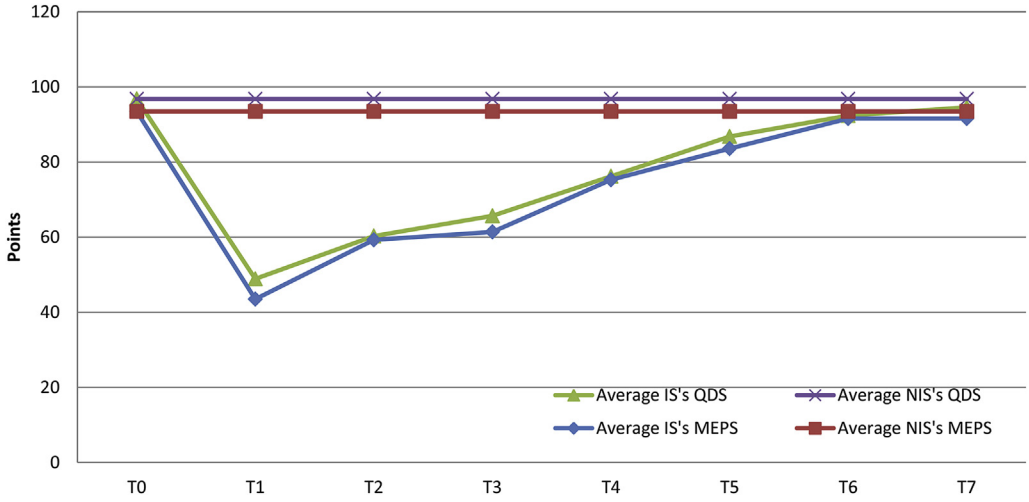

Fig. 3. Trends of the follow-up of the injured (IS) and not injured (NIS) side, measured by the Quick Dash Score (QDS) and by the Mayo Elbow Performance Score (MEPS). T0 before the trauma; T1 at the time of trauma; T2 at 4 weeks; T3 at 6 weeks; T4 at 8 weeks; T5 at 12 weeks; T6 at 26 weeks; T7 at 52 weeks from the trauma. For both scores, the complete recovery, as before the trauma ($p > 0.05$), took place at the 26 weeks follow-up (T6).

the 0° of extension, and two patients (5.40%) remained with a flexion contracture over the 3°: the first of 5° and the second of 7.5°. The mean supination was of 88.3° (range 81–90°) and mean pronation was of 82.7° (range 76–90°), which corresponded to 98.3% and 94.8% of NIS.

Twenty-seven patients (72.97%) returned to work after 52 weeks from the trauma. The other 10 patients (27.03%) returned to work after 64 weeks from the trauma.

There were no complications.

7. Discussion

Several studies report the success of both the single and the double incision techniques used to repair the distal biceps tendon.[10] But in a recent meta-analysis[11] frequent complications are reported too: neurapraxia of the cutaneous nerve is the most common complication in the single-incision group, occurring in 77 of 785 cases (9.8%), while the heterotopic ossifications are the most common complications in the double incision group, occurring in 36 of 498 cases (7.2%). The authors conclude that the complications are higher in the single incision procedure than in the double incision. The frequency of re-rupture complication and nerve damage are both higher, instead, the risk of heterotopic ossification is lower. Costopoulos et al.[12] have analyzed 105 patients treated with the double incision. The group that had taken indomethacin postoperatively, had a 0.96% rate of synostosis, compared to 37.50% for the untreated group ($p < 0.001$). No statistically significant difference was found between the means of fixation and synostosis. The authors concluded that the use of indomethacin after the distal biceps tenorrhaphy was associated with a statistically significant reduction of radioulnar synostosis and had no associated adverse effects, like gastrointestinal bleeding or rerupture, despite the prolonged use up to six weeks. Even Anakwenze et al.[13] had concluded that the prophylactic use of indomethacin reduced the chance of developing radioulnar synostosis. Kelley et al.[14] had complications in 31% of the patients treated with double incision technique. They reported five sensory nerve paresthesias: three due to lateral cutaneous antebrachial nerve and two superficial radial nerve paresthesias. A temporary paralysis of the posterior interosseous nerve, developed in one patient, was resolved in six months. Six patients complained of persistent pain in the front of the elbow. Heterotopic ossification that did not limit the forearm rotation developed in four patients, an infection of the wound surface developed in three patients, one rerupture of the tendon, three patients lost forearm rotation, and one patient developed a reflex sympathetic dystrophy.

The majority of morbidities from the repair of the distal biceps tendon have been attributed mainly to a delay in surgery, and secondarily to the extent of the anterior opening.[14] Besides the timing, what reduced the rate of complications was the surgical technique. In our case series, there wasn't any radioulnar synostosis as a result of the accuracy in isolating the tendon and the muscle-splitting modification of the double incision technique. Furthermore, the correct tunnel preparation is critical to guarantee the patient's functional recovery.[15] As shown in Fig. 2A, a flexible plastic trocar is used to protect the tendon flow in order to prevent cuts or injury by bone fragments and sharp edges, as used in the anterior cruciate ligament reconstruction surgery.[16] In addition, the creation of the bone tunnel is superior to the tension-slide construction in terms of both strength and stiffness as demonstrated by Jackson et al. for the ulnar collateral ligament reconstruction.[17] The simple final knot (Fig. 2B and C) averts the enlargement of the bone tunnel as seen with the use of Peek screws (38%) and poly-L-lactide (43%)[18]; being more anatomic and reducing complications compared with other fixation methods.[19] With this technique is also possible, as shown in Fig. 2D, obtain the intraoperative good tension of the distal biceps tendon, needed to contrast its tendency to elongate in the first four weeks after the surgery, as found by Marshall et al.[20] They showed a significant tendon elongation with a different technique, up to 2 cm, with the greatest amount of elongation found in the postoperative period, but extended also to the eighth week.

The complete rupture of the distal biceps tendon leads to a strong reduction of elbow flexion and forearm supination but seems not to affect endurance, even if patient feel early fatigue in activities requiring repetitive movements.[21] For this reason, we think that the rehabilitation should focus primarily on the improvement of the strength but also the resistance needs to be taken into consideration and improved. De Carli et al.[22] reported that at a mean follow-up of 84 months, the patients had subjective and objective satisfactory results. In our series flexion was recovered in all patients, while a supination deficiency of 10° was found in two patients. Our results on the functional recovery and return to work were in line with the findings reported in the literature, while the rate of complications is better since we didn't report any complication. Dynamometer tests showed also satisfactory results both for maximum power and resistance, attesting that the technique offers a good healing capacity, even if in our group we have had many smokers and a large number of alcohol consumers. Both this habits are proven to cause tissue hypoperfusion and decreased oxygenation of the tissues that may lead to poor tissue healing.

8. Conclusions

The "Salento technique", owing to its characteristics and attention in the surgical procedure, allows a safe repair of acute injuries of the distal biceps tendon with a low rate of complications. It provides also high patient satisfaction thanks to optimal mechanical and functional healing with a great recovery of both the strength and the endurance in supination and flexion.

Contribution of authors

All authors have made substantial contributions to all of the following: MF[4] and LM conceived of the study, participated in its design and coordination and helped to draft the manuscript, and revised it critically for important intellectual content, GR and RR drafted the manuscript, and carried out the statistical analysis and interpretation of data and revised it critically for important intellectual content, PP, MB and MF[1] collected the data, helped to draft the manuscript, carried out the review of the literature.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcot.2019.02.006.

Appendix A

Description of Rehabilitative Protocol

1. During the first postoperative week, the patient keeps an opened plaster cast in a functional position.
2. Second and third weeks: the plaster cast is replaced by a Hinged Elbow Brace (ROM allowed: 45°–180°).

Exercises for the range of motion improvement (without the brace).

- Passive elbow flexion and supination (with elbow at 90°)
- Assisted elbow extension and pronation (with elbow at 90°)
- Active and passive elbow mobilization, avoiding excessive extension (not below 45°)

Strengthening Program.

Week 2: Sub-maximal pain-free biceps isometrics with the forearm in neutral.
Week 3: Single plane isotonic exercises in flexion, extension, supination, and pronation.

3. From 4th to 6th week

ROM allowed with the Hinged Elbow Brace: Week 4, 30° to full elbow flexion; Week 5, 20° to full elbow flexion; Week 6, 10° to full elbow flexion.
Exercises for the range of motion improvement (without brace).

- Active ROM elbow flexion and extension

Strengthening Program: Single plane isotonic exercises in flexion, extension, supination, and pronation.

4. From 7th to 11th week

Hinged Elbow Brace with full ROM allowed; discontinue brace if adequate motor control is gained.
Exercises for the range of motion improvement.

- Continue program as above
- May begin combined/composite motions (i.e. extension with pronation).
- If at 8 weeks post-op the patient has significant ROM deficits therapist may consider more aggressive management, after consultation with referring surgeon.

Strengthening Program.
Progressive resistance and force exercise program is initiated for elbow flexion, extension, supination, and pronation.

5. Week 12: The Hinged Elbow Brace is removed

Strengthening Program.
Progressive elbow and shoulder strengthening program.

- May initiate light upper extremity weight training.
- Initiate endurance program that simulates desired work activities/requirements.

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