

# Intraoperative Estimation of the Popeye Sign by Electrical Stimulation of the Musculocutaneous Nerve Following Shoulder Biceps Tenotomy



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**Abstract:** Younger patients in particular may require biceps tenodesis following tenotomy to avoid the development of a biceps “Popeye deformity.” It is, however, difficult to predict whether a tenodesis is cosmetically necessary, since this deformity develops to a very variable degree, as the biceps muscle will retract in the postoperative course to an unknown amount with active contraction. Through the intraoperative electrical stimulation of the musculocutaneous nerve, the maximal contraction of the muscle can intraoperatively be provoked and thus the amount of Popeye deformity becomes apparent. We conclude that this method could be useful for intraoperative decision making if biceps tenodesis is needed and helps to avoid this surgical step and its associated risks, which otherwise often is performed unnecessarily, just in case.

The 2 most common surgical treatments for lesions of the long head of biceps muscle are biceps tenotomy and tenodesis.<sup>1-8</sup> In the current literature, there is ample evidence supporting either procedure, and there is little doubt that in most circumstances both of them yield favorable clinical results.<sup>2,6,9</sup> Still, the benefits of biceps tenodesis beyond cosmesis remain somewhat controversial,<sup>1-5,8</sup> mainly due to the various functions attributed to the long head of biceps muscle. Whereas some authors describe the long head of biceps muscle as a humeral head depressor, anterior and posterior shoulder stabilizer, and glenoid labrum elevator,<sup>10</sup> others declare it as an embryonic vestige without any active function.<sup>11</sup>

Although tenotomy of biceps muscle is seen as a well-tolerated technique with an overall 97% satisfaction rate,<sup>12</sup> possible impairments such as a loss in elbow flexion and forearm supination strength are disputed,<sup>13-15</sup> whereas others disagree with this

correlation.<sup>5</sup> The only undisputed drawback of biceps tenotomy is an occasional muscle deformity with occurrence of the so-called Popeye sign<sup>2,6,9</sup> in up to 70%<sup>15</sup>; however, without functional consequence.<sup>2</sup> Nevertheless, the risk for the unfavorable cosmetic aspect of biceps deformity remains. Therefore, in clinical practice, an important percentage, particularly younger patients or manual laborers,<sup>1</sup> still demand the procedure of biceps tenodesis, mainly due to the esthetical uncertainty if a Popeye sign could occur after biceps tenotomy.<sup>1,9</sup>

As the biceps tendon will retract in the postoperative course to an unknown extent due to active muscle contraction, it is difficult to estimate by the intraoperative aspect whether a tenodesis is cosmetically necessary. The following technical tip reports a new approach to achieve intraoperative muscle contraction by direct stimulation of the musculocutaneous nerve to predict whether postoperative Popeye deformity after tenotomy will occur.

## Indication

In patients with tendinitis of the biceps long head tendon, an arthroscopic tenotomy of the long head of the biceps muscle can be performed. After tenotomy, there can be reasonable doubt if postoperative Popeye deformity might occur. This can be particularly the case in patients of young age, with high sporting demands or asthenic body composition. Hence, intraoperative estimation of a possible postoperative Popeye deformity may present a useful opportunity to decide whether

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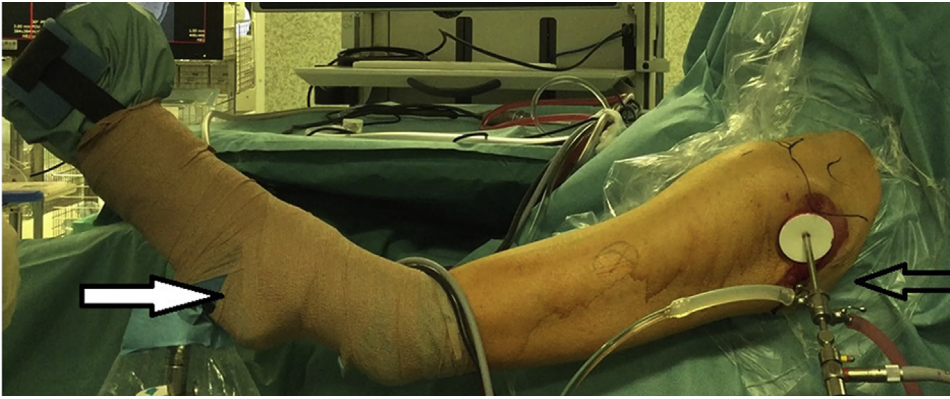
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**Fig 1.** Left shoulder in a 43-year-old male patient in the beach chair position with the index arm in the SPIDER Limb Positioner (white-filled arrow). The 30° angle telescope is inserted through the dorsal viewing portal (transparent arrow) to perform diagnostic arthroscopy for evaluation of the quality and the position of the biceps tendon.

biceps tenodesis is necessary. Therefore, stimulation of the musculocutaneous nerve can be performed to achieve a maximal retraction of the biceps muscle belly.

## Surgical Technique

### Assessment of Biceps Pathology

For arthroscopy, the patient is placed in the beach chair position with the index arm in the SPIDER Limb Positioner (Smith & Nephew, Watford, UK) for various levels of abduction, forward flexion, and external rotation. Regional interscalene nerve block anesthesia is administered. The standard shoulder arthroscopy begins with the inspection of the glenohumeral joint through the dorsal viewing portal with a 30° angle telescope (Fig 1). Besides examination of the joint cartilage and of the rotator cuff, special focus should be placed on the biceps tendon. Hereby, the tendon's quality and its position are evaluated to notice possible degeneration, splits, and luxation. When biceps tendinopathy or biceps-related pathology is confirmed, biceps tenotomy is performed (Fig 2).

### Musculocutaneous Nerve Stimulation Procedure (With Video Illustration)

At this point of the surgery, the surgeon evaluates whether the Popeye deformity is likely to appear in the postoperative course after biceps tenotomy, making biceps tenodesis necessary. This decision can be challenging, as no prediction about the postoperative cosmetic acceptance can be made from the intraoperative appearance of the muscle belly. Therefore, retraction tendency of the long biceps tendon can be assessed by intraoperative electrical stimulation of the musculocutaneous nerve. A 75-mm, 22-gauge needle attached to the nerve stimulator Stimuplex HNS 12 (Braun, Kronberg, Germany) is set at electric current 1.8-2 mA, frequency 2.0 Hz, and pulse width 0.3 milliseconds (Fig 3). The puncture point on the skin through which the stimulation needle is inserted lies in the groove palpable between the biceps muscle and the

humerus, 4 transverse fingers distal to the axillary fold. The needle is inserted from that point in a strictly coronal plane from medial ventral to the humerus. In this direction, the neurovascular bundle can safely be avoided (Fig 4). By stimulating during insertion of the needle, the optimal position with maximal motor response (elbow flexion) to the stimulus is detected. The contraction of the biceps tendon occurs synchronously to the rhythm of the stimulator (Fig 5, Video 1). When good motor response is achieved, a reduction of the pulse width to 0.1 milliseconds and of the electric current to 0.2 mA is performed. Simultaneously to the maximal motor response of the biceps tendon inside the joint, the deformity can be seen on the upper arm. As



**Fig 2.** Left shoulder in a 43-year-old male patient during diagnostic arthroscopy through the dorsal viewing portal. On the screen, tendinopathy of the biceps tendon is portrayed (white-filled arrow).



**Fig 3.** Left shoulder in a female cadaver (Institute of Anatomy, University of Zurich, Zurich, Switzerland) for demonstration of electrical stimulation of the musculocutaneous nerve to evaluate intraoperatively if Popeye deformity might appear in the postoperative course after biceps tenotomy. A 75-mm, 22-gauge needle is attached to the nerve stimulator Stimuplex HNS 12 and then set at electric current 1.8-2 mA, frequency 2.0 Hz, and pulse width 0.3 milliseconds.

the physical appearance corresponds to the maximum postoperative deformity, a Popeye sign can be predicted if prominent bulging of the biceps is present. In this case, the surgeon can decide for biceps tenodesis. On the other side, there is no need to perform tenodesis after tenotomy if no noticeable protrusion of the muscle belly is seen on the upper arm. We consider it preferable to perform this procedure early during surgery to avoid swelling of the arm and to later proceed with either rotator cuff repair, resection of acromioclavicular joint, or latissimus dorsi transfer. [Table 1](#) presents pearls and pitfalls, and [Table 2](#) shows advantages and disadvantages.

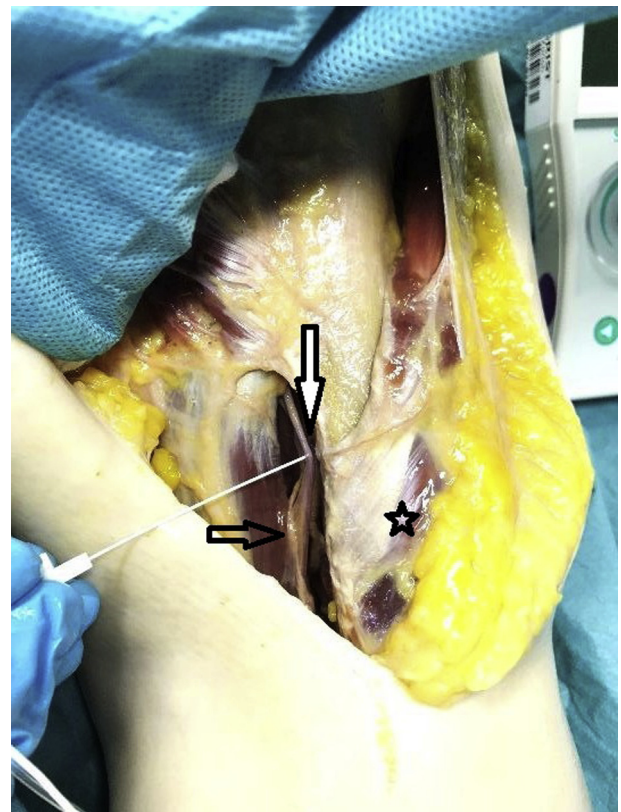
#### Performance of Biceps Tenotomy and Tenodesis

The anterior working portal is established, dissecting the tissue between the superior and the middle glenohumeral ligament. After establishing a maximal motor response by electrical stimulation of the musculocutaneous nerve, biceps tenotomy is performed with a 15-blade scalpel through the anterior portal ([Fig 6](#)). An

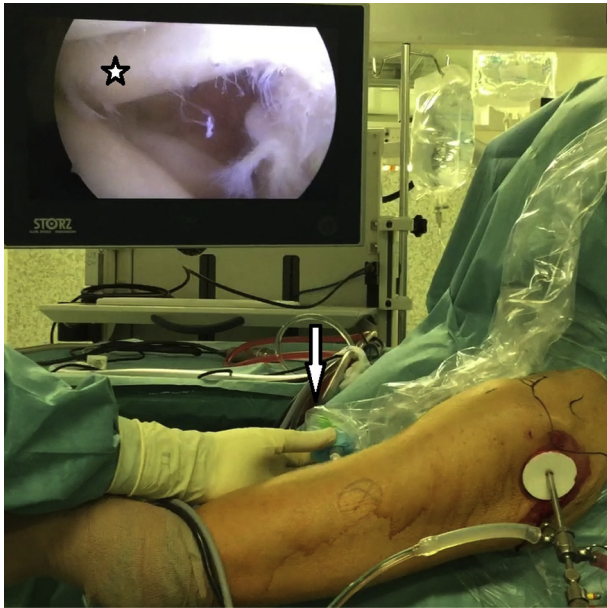
immediate retraction of the tendon from the joint is documented ([Video 1](#)). If tenodesis is considered necessary, the next step constitutes performing biceps tenodesis. A lateral subacromial portal is established and the sulcus bicipitalis gently debrided with a shaver (e.g. DRILLCUT-X ARTHRO; Karl Storz, Tuttlingen, Germany) to remove inflamed tissue. The detached biceps tendon is luxated from the sulcus and a self-tapping Titanium Suture Anchor (diameter 5 mm, length 12.5 mm; Karl Storz) is inserted into the sulcus at the upper margin of the pectoralis major tendon. The luxated biceps tendon is grasped, shortened by approximately 4 cm, and attached to the sulcus with a nonabsorbable, high molecular polyethylene suture (MEGAFIBRE sutures USP 2; Karl Storz) with baseball stitches. The last step includes hemostasis, removal of the instruments, and wound closure with single button sutures.

#### Postoperative Procedure

The sole biceps tenotomy does not need any special postoperative treatment, the active and passive range of



**Fig 4.** Left shoulder in a female cadaver (Institute of Anatomy, University of Zurich, Zurich, Switzerland) with an open anterior approach for demonstration of the stimulation needle's insertion into the musculocutaneous nerve (white-filled arrow). The nerve is located between the M. coracobrachialis medially (transparent arrow) and the M. biceps brachii laterally (star) in the upper third of the humerus.



**Fig 5.** Left shoulder in a 43-year-old male patient. The stimulation needle is inserted anterior to the humerus in the coronal plane from medial into musculocutaneous nerve (white-filled arrow). Electrical stimulation of the nerve is performed and maximal motor response of the biceps muscle achieved. Simultaneously to the contraction of the biceps tendon inside the joint (seen on the screen, star), a slight bulging of the biceps muscle can be evaluated on the upper arm.

motion is free, and the weight bearing of the arm can be increased after removal of the stitches according to the

individual complaints. A sling can be applied when necessary.

Biceps tenodesis requires protection of the biceps tendon. Hence, active elbow flexion is disallowed for 6 weeks and forced elbow flexion against resistance is refrained for 12 weeks postoperatively. A sling is prescribed for 4 weeks.

## Discussion

The optimal surgical treatment for biceps pathology is a frequent topic in the current literature<sup>1-8</sup> and both biceps tenotomy and tenodesis are equally advocated.<sup>1-5</sup> In both techniques, the biceps tendon is first released proximally from its damaged position in the anterior glenohumeral joint and as a result the tendon will retract in the bicipital groove. In contrast to biceps tenotomy, where the biceps tendon is not fixed on the bone, in biceps tenodesis the effort is made to attach the tendon to the bicipital groove.<sup>14,16-18</sup> Therefore, postoperative complications in tenodesis are linked to the individual technique applied: injuries of neurovascular structures,<sup>16</sup> proximal humerus fractures,<sup>17</sup> implant failure and disturbing external material,<sup>18</sup> frozen shoulder, and infection.<sup>7,9,15</sup> Biceps tenodesis is a more challenging procedure involving a longer surgical time and more delicate rehabilitation.<sup>14</sup> In contrast to tenodesis, biceps tenotomy is a popular, technically simple procedure involving minimal time of operation and rehabilitation with

**Table 1.** Pearls and Pitfalls

Pearls	Pitfalls
A 75-mm, 22-gauge needle is attached to the nerve stimulator Stimplex HNS 12 (Braun) and set at electric current: 1.8-2 mA, frequency 2.0 Hz, and pulse width 0.3 ms.	Insertion of the stimulation needle too medially and posterior to the humerus or in a medial divergently direction (and not strict coronal plane) can result in damage of neurovascular bundle with bleeding of the A. brachialis or motoric and sensorial deficiency of the affected limb.
One hand palpates the neurovascular bundle medial and proximally posterior to the humerus.	Low electric current or pulse width may not lead to maximal motor response resulting in underestimation of biceps deformity.
The other hand inserts the stimulation needle anterior to the humerus in the coronal plane from medial into the visible proximal aspect of the biceps (avoidance of damage to neurovascular bundle).	Decision for biceps tenotomy or tenodesis is made from the surgeon's point of view, a lack of generalizability has to be minded.
When good motor (elbow flexion) response is achieved, the pulse width is reduced to 0.1 ms and the electric current is reduced to 0.2 mA.	
Simultaneously to the maximal motor response, the contraction of the biceps tendon inside the joint is visible.	
If estimated deformity of biceps muscle according to maximal motor response to stimulus matches with esthetical demanding of the patient, biceps tenotomy is performed.	
If estimated deformity of biceps muscle does not match with esthetical demanding of the patient and Popeye sign is suspected, biceps tenotomy and consecutive biceps tenodesis is performed.	
Biceps tenotomy is performed early during surgery to avoid swelling of the arm.	

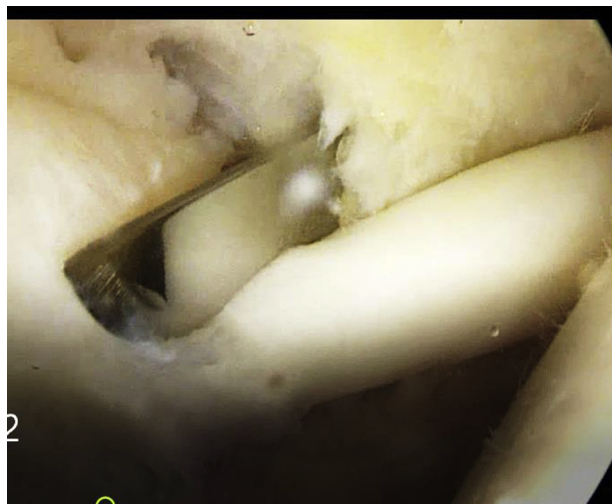
**Table 2.** Advantages and Disadvantages

Advantages	Disadvantages
Reliable intraoperative estimation of postoperative cosmetic result after biceps tenotomy	Additional time exposure (60-120 s)
Assistance for patient-specific decision between biceps tenotomy or tenodesis	Possibility of damage of neurovascular bundle
Biceps tenotomy is associated with good functional, pain, and satisfaction outcome	
Technique is simple, safe, fast, reproducible, and inexpensive	

immediate mobilization and return to activity.<sup>15</sup> Impairments associated with biceps tenotomy stated in the literature include loss of muscle strength in elbow flexion and forearm supination<sup>13-15</sup> and cramping due to missing anatomical restitution and proximal tendon fixation.<sup>1,3,4,6,7,9</sup> When performing tenodesis, tendon length is assumed to be maintained by a new proximal fixation, resulting in approximately maintained muscle tension and in avoidance of muscle atrophy,<sup>14</sup> yet some authors link a greater rate of postoperative residual pain in the bicipital groove to biceps tenodesis.<sup>1,2</sup> Therefore, the assumed biomechanical advances of biceps tenodesis appear to be clinically outweighed by the potential associated problems.<sup>5</sup>

### Conclusions

The here-described technique with use of electrical stimulation of musculocutaneous nerve allows the surgeon in a quick and safe way to intraoperative visually estimate the postoperative cosmetic result of biceps tenotomy. This allows for intraoperative decision-making if biceps tenodesis is needed and helps to avoid this surgical step and its associated risks, which otherwise is often performed unnecessarily, just in case.



**Fig 6.** Intraoperative performance of tenotomy of long head of biceps tendon with a 15-blade scalpel is shown on the screen of the arthroscopy system.

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