

# Effects of Biceps Tenotomy on The Shoulder Joint in the Treatment of Slap Lesions

## *Slap Lezyonlarına Uygulanan Biceps Tenotomisinin Omuz Eklemine Etkileri*

Caner POYRAZ<sup>1</sup>, Vahit YILDIZ<sup>1</sup>

<sup>1</sup> Adnan Menderes University, Faculty of Medicine, Department of Orthopaedics and Traumatology, Aydın, Türkiye

### Özet

**Amaç:** Bu çalışmada izole SLAP (Superior Labrum Anterior To Posterior) lezyonlarında biceps tenotomisi sonrası omuz eklemine radyolojik ve klinik değişikliklerin araştırılması amaçlandı.

**Gereç ve Yöntemler:** Eylül 2015 ile Eylül 2019 tarihleri arasında merkezimizde SLAP lezyonları için omuz artroskopisi yapılan toplam 380 hasta retrospektif olarak analiz edildi. Çalışmaya dahil edilme kriterlerini karşılayan 44 hasta dahil edildi (izole SLAP lezyonu, biceps tenotomisi, omuz instabilitesi yok, ileri omuz artrozu yok, ek omuz patolojisi yok, takip süresi 1 yıldan uzun). Hastaların ameliyat öncesi ve sonrası değerleri klinik ve radyolojik ölçümlerle karşılaştırıldı. Klinik değerlendirilmede; UCLA, Constant, VAS, DASH skorlama sistemi ve kas gücü karşılaştırıldı. Radyolojik değerlendirilmede; Superior Humeral Migrasyon, Korakohumeral Mesafe, Akromiohumeral Mesafe, Kritik Omuz Açısı, Akromiyal İndeks karşılaştırıldı.

**Bulgular:** Çalışmaya dahil edilen 44 hastanın 18'i kadın, 26'sı erkekti. Hastaların ortalama yaşı 51 ve ortalama takip süresi 32,2 aydı. Hastaların ameliyat öncesi ölçümlerinde Korakohumeral Mesafe:  $11,5 \pm 2,4$  mm, Humerus Başı Superior Migrasyonu:  $3,4 \pm 1,0$  mm idi. Ameliyat sonrası grup ölçümlerinde Korakohumeral Mesafe:  $8,4 \pm 1,4$  mm, Humerus Başı Superior Migrasyonu:  $4,5 \pm 1,3$  mm. Bu değerler karşılaştırıldığında, SHY ve KH mesafesi değerlerindeki değişiklikler istatistiksel olarak anlamlıydı ( $p=0,031$ ,  $p=0,012$ ). Klinik değerlendirmeler kapsamındaki tüm fonksiyonel ölçümlerde ve skorlama sistemlerinde istatistiksel olarak anlamlı iyileşmeler gözlemlendi.

**Sonuç:** İzole SLAP lezyonlarının tedavisinde biceps tenotomisi, radyolojik olarak humerusun anterior ve superior translasyonu ile sonuçlandı. Klinik değerlendirmelere göre, tenotomi bu hastalarda ağrının giderilmesine ve fonksiyonun iyileşmesine katkıda bulunmaktadır.

**Anahtar Kelimeler:** SLAP lezyonu, Biceps Patolojisi, Superior Humeral Oryantasyon, Korakohumeral Mesafe, Biceps Tenotomisi.

### Abstract

**Objective:** This study aimed to investigate the radiologic and clinical changes in the shoulder joint after biceps tenotomy for isolated SLAP (Superior Labrum Anterior to Posterior) lesions.

**Material and Methods:** A total of 380 patients who underwent shoulder arthroscopy for SLAP lesions between September 2015 and September 2019 in our center were retrospectively analyzed. The study included 44 patients who met the inclusion criteria (isolated SLAP lesion, biceps tenotomy, no shoulder instability, no advanced shoulder arthrosis, no additional shoulder pathology, follow-up period longer than 1 year). Post operative and pre-operative values of the patients were compared with clinical and radiologic measurements. In clinical evaluation; UCLA, Constant, VAS, DASH scoring system and muscle strength were compared. In radiologic evaluation; Superior Humeral Migration, Coracohumeral Distance, Acromiohumeral Distance, Critical Shoulder Angle, Acromial Index were compared.

**Results:** Among the 44 patients included in the study, 18 were female and 26 were male. The mean age of the patients was 51 years and the mean follow-up period was 32.2 months. In the preoperative measurements of the patients, Coracohumeral Distance:  $11.5 \pm 2.4$  mm, Superior Migration of the Humeral Head:  $3.4 \pm 1.0$  mm. In the postoperative group measurements, Coracohumeral Distance:  $8.4 \pm 1.4$  mm, Superior Migration of the Humeral Head:  $4.5 \pm 1.3$  mm. When these values were compared, the changes in the SHY and KH distance values were statistically significant ( $p=0.031$ ,  $p=0.012$ ). Significant improvements were observed in all functional measurements and scoring systems within the scope of clinical evaluations.

**Conclusion:** Biceps tenotomy in the treatment of isolated SLAP lesions resulted in anterior and superior translation of the humerus radiologically. According to clinical evaluations, tenotomy contributes to pain relief and improved function in these patients.

**Keywords:** SLAP lesion, Biceps Pathology, Superior Humeral Orientation, Coracohumeral Distance, Biceps Tenotomy.

**Correspondence:** Vahit YILDIZ, Adnan Menderes University, Faculty of Medicine, Department of Orthopaedics and Traumatology, 09100, Aydın, Türkiye.

**Phone:** +90 505 293 27 83 **e-mail:** dr.vyildiz44@hotmail.com

**ORCID No (Respectively):** 0000-0002-3169-2455, 0000-0003-3639-0912

**Submission date:** 20.10.2024

**Acceptance date:** 23.01.2025

**DOI:** 10.17517/ksutfd.1570649

## INTRODUCTION

The effects of the long head of the biceps tendon on shoulder have been described by guesswork and hearsay for a long time. It is known that the biceps tendon is often a source of pain in shoulder pathologies (1). However, there is no consensus on the functions and working mechanism of this tendon. Many authors have suggested that the long head of the biceps tendon is a rudimentary structure similar to the palmaris longus tendon in the wrist, while others have reported that the tendon has a critical role in shoulder proprioception and dynamic and static stabilization (2–4).

Recently, SLAP (Superior Labrum Anterior to Posterior) lesions are diagnosed 4 times more frequently due to technological advances and the increase in the popularity of arthroscopic surgery (5). Repetitive traumas are prominent in the etiology of SLAP. It has been reported in the literature that the long head of the biceps tendon causes this trauma with the effect of traction, especially in type 2 SLAP lesions (6). In traditional surgical treatment, it has been shown that the previously reported high success rates in the repair of SLAP lesions with anchor sutures cannot be achieved and the frequency of biceps tenotomy/tenodesis operations has become more frequent (7). In our study, changes in shoulder structure and function in patients who underwent biceps tenotomy were examined. Humeral migration, position of the humeral head in the joint and functional changes were evaluated. It is hypothesized that the humerus will be migrated superiorly with the removal of the depressor effect and the symptoms related to the SLAP lesion will be relieved with the reduction of the traction effect.

## MATERIALS AND METHODS

The clinical and radiologic findings of patients who underwent shoulder arthroscopy for isolated SLAP lesions between September 2015 and September 2019 in our clinic were evaluated retrospectively. A total of 380 patients were retrospectively reviewed from the orthopedic arthroscopy archive. Among these patients, 44 patients who underwent biceps tenotomy were included in the study. Patients with a follow-up period of less than 12 months, patients who did not come for follow-up, patients who underwent primary repair or tenodesis of SLAP lesion, patients who did not have MRI examination at postoperative controls, patients who had additional pathology with SLAP lesion, and patients who underwent any previous shoulder operation were excluded from the study. All operations were performed by a single surgeon. All patients included in the study were evaluated clinically, functionally, radiologically and cosmetically. In clinical evaluation;

UCLA, Constant, VAS, DASH scoring system and muscle strength were compared with preoperative values.

## Radiological measurements

In the radiologic examination of the patients, direct radiographs and preoperative MR imaging were evaluated. The evaluation of the humeral head and glenoid status, presence of defects and comorbid pathologies were evaluated on the radiographs. The presence and degree of SLAP lesion and accompanying soft tissue pathologies were evaluated in MR imaging. X-ray and MR images were repeated at the first postoperative year controls. Preoperative and postoperative radiologic measurements were made on X-ray and MR images. Acromiohumeral Distance, Coracohumeral Distance, Superior Humeral Migration, Critical Shoulder Angle, Acromial Index were evaluated.

*Acromiohumeral Distance (AH):* Measurement of the shortest distance between the acromion and humeral head in axial views (8,9) (**Figure 1**).

*Coracohumeral Distance (CH):* Measurement of the shortest distance between the coracoid process and the tuberculum minus in axial and sagittal sections (10,11) (**Figure 2**).

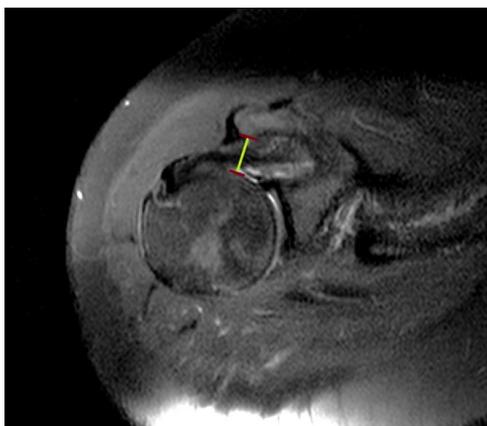
*Acromial Index (AI):* The ratio of the distance from the glenoid articular surface to the outer border of the acromion and the distance from the glenoid articular surface to the outer border of the tuberculum majus on true AP radiographs (12) (**Figure 3**).

*Critical Shoulder Angle (KOA):* Measurement of the angle between the parallel line placed on the glenoid articular surface and the lower outer corner of the acromion on true AP radiographs (13) (**Figure 4**).

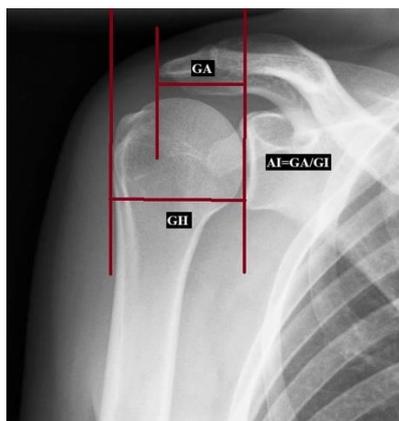
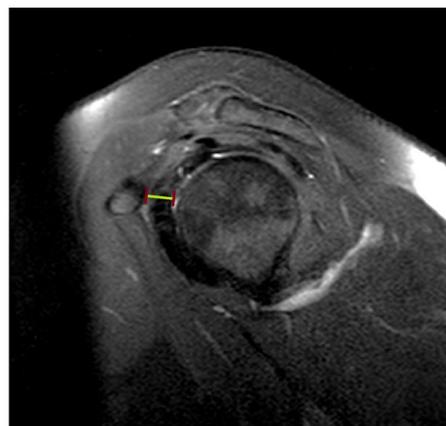
*Superior migration of the humeral head (SHM):* Measurement of the distance between the center of the joint face and the center of the humeral head in the sagittal plane (8,14) (**Figure 5**).



**Figure 1.** Acromiohumeral distance measurement



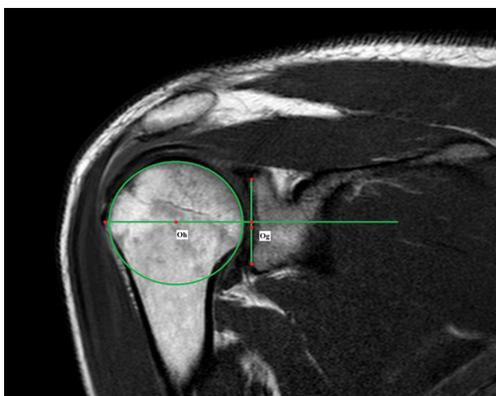
**Figure 2.** Coracohumeral distance measurement



**Figure 3.** Acromial Index measurement



**Figure 4.** Critical Shoulder Angle measurement



**Figure 5.** Superior migration of the humeral head (SHM) measurement

### Statistical Analysis

IBM SPSS Statistics 26 program was used for statistical analysis of the data. Numerical data were calculated as mean and standard deviation, while categorical data were calculated as frequency and percentage. Descriptive statistics were used to evaluate the data of the patients. The Kolmogorov-Smirnov test was used to evaluate whether the data were normally distributed. Parametric statistical methods were used for normal-

ly distributed variables. Paired t test was used as parametric test. Wilcoxon Signed Rank test was applied to variables that did not show normal distribution. The statistical significance limit (p) was evaluated as 0.05.

### RESULTS

A total of 380 patients who underwent shoulder arthroscopy for SLAP lesions were retrospectively analyzed from the shoulder archive. Among these patients, 44 were included in the study with isolated SLAP lesions and intact biceps tendon. It was confirmed that biceps tenotomy was performed in all 44 patients included in the study. The mean age of the patients was 51 years (37-65) and the follow-up period was 32.2 months. Eighteen of the patients were female (40.9%) and 26 were male (59.1%). 65.1% of the lesions were on the right shoulder and 34.9% on the left shoulder. The lesions were on the dominant hand side in 31 (70.4%) and on the non-dominant hand side in 13 (29.6%) of the patients (**Table 1**). The preoperative diagnosis of the patients was confirmed by MRI scans, clinical examination findings, video recordings and intraoperative operative notes.

**Table 1. Demographic Data of Patients**

<b>Gender</b>	Female	18 (%40.9)
	Male	26 (%59.1)
<b>Age(year)</b>		Mean: 51,63 (37–65)
<b>Follow-up Period (month)</b>		Mean: 32.2
<b>Affected side</b>	Right	28 (%65)
	Left	16 (%35)

### Clinical Results

In the preoperative and postoperative comparative analysis of the patients who underwent arthroscopic biceps tenotomy for SLAP lesion, the preoperative mean Constant Score was 50 (10-70) and the postoperative mean Constant Score was 79.4 (33-99). According to the VAS Scoring system, the preoperative mean value was 6.2 (5-8), while the postoperative mean value was 2.5 (0-4). According to the DASH Scoring system, the preoperative mean value was 13.2 (11-15) and the postoperative mean value was 9.6 (8-11). According to the UCLA Scoring system, the preoperative mean value was 9.0 (6-12) and the postoperative mean value was 29.06 (17-35). There was a statistically significant improvement in all scoring systems after tenotomy compared to preoperative values ( $p<0.05$ ). According to the VAS scoring system, the preoperative mean VAS score was 6.2 (5-8) and the postoperative value was determined as 2.5 (0-4) with a 59.67% improvement (**Table 2**).

According to the Medical Research Council system, muscle strength levels of the patients were determined in preoperative and postoperative examinations. Accordingly, the mean deltoid muscle strength was 4.01(3-5) preoperatively and 4.64 (4-5) postoperatively. When these values were compared, it was determined that there was a statistically significant increase in deltoid muscle strength after tenotomy ( $p<0.05$ ). Biceps muscle strength was 2.95(2-4) preoperatively and 4.01(3-5) postoperatively. When these values were compared, it

was determined that there was a statistically significant increase in biceps muscle strength after tenotomy ( $p<0.05$ ).

In our study, complications such as ‘Popeye’s Sign’, tenderness in the bicipital groove and cramping pain did not occur in a total of 44 patients who underwent tenotomy. Skin reaction developed in a total of 3 patients and was treated with simple medical applications.

### Radiological Findings

The preoperative mean AH distance of the patients who underwent biceps tenotomy for SLAP lesion was  $6.41 \pm 1.29$  mm (min-max =3.2-15.1 median=6.8) and the postoperative mean was  $6.49 \pm 1.07$  mm (min-max =2.9-14.8 median=6.5). The preoperative mean CH distance was  $11.53 \pm 2.44$  mm (min-max =2.19-26.1 median=11.3) and the postoperative mean was  $8.48 \pm 1.41$  mm (min-max =1.77-18.9 median=9.9). The preoperative mean of the preoperative SHM was  $3.48 \pm 1.02$  mm (min-max =2.5-12.7 median=4.6) and the postoperative mean was  $4.52 \pm 1.33$  mm (min-max =3.1-16.4 median=4.9). Preoperative mean CSA was  $43.50 \pm 6.66^\circ$  (min-max =33°-61° median=43°) and postoperative mean was  $43.31 \pm 5.98^\circ$  (min-max =32°-64° median=44°). The mean preoperative AI was  $0.50 \pm 0.11$  (min-max =0.6-1.12 median=0.82) and the mean postoperative AI was  $0.53 \pm 0.14$  (min-max =0.8-1.23 median=0.77).

**Table 2. Comparison of Scoring Systems Results**

	<b>Preoperative</b>	<b>Postoperative</b>	<b>p</b>
<b>Constant Score</b>	50 (10-70)	79.4 (33-99)	( $p<0.05$ )
<b>VAS</b>	6.2 (5-8)	2.5 (0-4)	( $p<0.05$ )
<b>DASH</b>	13.2 (11-15)	9.6 (8-11)	( $p<0.05$ )
<b>UCLA</b>	9.0 (6-12)	29.06 (17-35)	( $p<0.05$ )

Significant difference was found in SHM and CH values in postoperative measurements when compared to preoperative values in patients who underwent biceps tenotomy operation due to SLAP lesion (Table 3).

## DISCUSSION

In our study, we examined the effects on shoulder biomechanics of biceps tenotomy, which is currently used in the surgical treatment of Slap lesions. Tenotomy is preferred by clinicians because of its short operation time, low complication rate and easy applicability. Clinical improvement was evaluated as a decrease in the traction effect on the biceps labrum complex. In addition, it causes migration of the humeral head superiorly and anteriorly.

The initial treatment of SLAP lesions is mostly conservative treatment. Surgical treatment is recommended for patients whose pain does not improve despite conservative treatment and who cannot reach their previous activity level. Arthroscopic SLAP lesion repair, SLAP lesion repair with biceps tenodesis or biceps tenotomy, solely biceps tenotomy are among the treatment options (15,16). The preference between tenodesis and tenotomy operations is based on the patient's age, level of function, being an athlete and cosmetic expectations(15). In a study conducted by Molnar *et al.* in 2020, SLAP lesions in elite amateur wrestlers were treated using biceps tenodesis and tenotomy method. The data obtained in this study showed that optimum functional performance can be regained in athletes after biceps tenotomy (17). Our preference in our operations is the biceps tenotomy procedure because it offers shorter operation time, earlier rehabilitation opportunities, and we rarely encounter complications mentioned in the literature.

The popularity of biceps tenotomy has been increasing, and studies examining the effects of LHBT on the shoulder joint have also been gaining popularity. These studies have found that the biceps long head tendon provides dynamic stabilization to the shoulder joint (18). Superior migration of the humeral head was first studied by Golding in the 1960s. Weiner and Macnabise conducted research on this subject in 1970. Due to dysfunction, rupture or tenotomy of the biceps tendon, it was thought that the removal of the depressor force of the biceps tendon on the humeral head caused superior migration of the humeral head, which resulted in a decrease in the acromiohomeral distance. In this sense, a study conducted in 2005 showed that 379 patients had decreased acromiohomeral distance and fatty degeneration of the infraspinatus muscle after tenotomy/tenodesis (19,20). In their biomechanical studies, Pagnani *et al.* showed that in isolated anterosuperior labrum lesions, there was no anteroposterior or superoinferior translation of the glenohumeral joint when the supraglenoid origin of the long head of the biceps was intact. However, in cases where the superior labrum is completely torn, in other words, when the biceps-labrum complex becomes unstable, studies have reported a significant increase in superoinferior and anteroposterior translation (21,22). Burkat *et al.* found that anterior and anteroinferior translation increased at 30 and 60 degrees of abduction in simulated SLAP lesions in cadaveric studies. In addition, the authors stated that SLAP lesion repair provides normal biomechanics and contributes to glenohumeral stability (23,24). In the examinations performed in our study, we found statistically significant differences in terms of SHM in patients who underwent tenotomy. In accordance with the literature, the most important outcome of our study was the detection of superior migration of the humeral

**Table 3. Comparison of Radiological Results**

	Preoperative	Postoperative	p
Acromiohumeral Distance (AH)	6.41± 1.29 mm	6.49 ± 1.07 mm	(p=0.220)
Coracohumeral Distance (CH)	11.53±2.44mm	8.48 ± 1.41 mm	(p=0.012)
Superior Humeral Migration (SHM)	3.48±1.02mm	4.52 ± 1.33 mm	(p=0.031)
Critical Shoulder Angle (CSA)	43.50±6.66°	43.31 ± 5.98°	(p=0.25).
Acromial Index (AI)	0.50 ± 0.11	0.53 ± 0.14	(p=0.598)

head with the elimination of the depressor function of the long head of the biceps tendon. In a study on biceps tendon rupture conducted in 2019, coracohumeral distance and coracoid indices were evaluated and it was determined that an increase in these distances correlated with biceps rupture (25). According to a clinical study, Alexander *et al.* reported that isolated biceps tenotomy may increase anterior shoulder instability regardless of whether the superior labrum is intact or not (26). Similar results were obtained in our study by finding that the CH distance was significantly decreased in patients who underwent tenotomy. The finding that the coracohumeral distance was decreased in biceps long head ruptures and tenotomy is a significant result indicating that the biceps long head tendon is an important factor in the anterior stability of the humeral head.

A study by Gill *et al.* in 2001, in which a total of 30 patients were examined and the mean age was 50 years, patients were evaluated in the postoperative period after biceps tenotomy. Patients reported a significant reduction in pain and functional improvement (27). In another study conducted by Boileau *et al.* in 2007, it was reported that biceps tenotomy/tenodesis treatment would increase athletic performance in athletes due to the elimination of the pain source (28). Szabo *et al.* reported that tenotomy/tenodesis performed in patients with biceps pathology with rotator cuff pathology, even if it did not provide shoulder strengthening, gave satisfactory results in terms of pain reduction and functional range of motion, while it was simple and had low complication and reoperation rates (20). Earlier studies in the literature have also reported pain and loss of function after tenotomy, and a 1998 study by Carpenter *et al.* showed a 20% spontaneous loss of forearm supination strength and 8-20% spontaneous loss of elbow flexion strength after tenotomy (29). Koh *et al.* performed biceps tenotomy in 41 patients with biceps pathology. They reported the complications of “Popeye sign”, pain during elbow flexion and decreased elbow flexion strength with a rate of 27% in the postoperative period. When contraction pain and elbow flexion strength were compared, there were no significant differences (30). In a similar study, Kelly *et al.* reported that out of 160 patients who underwent tenotomy, 70% had “Popeye’s sign” and 38% complained of pain and loss of strength during flexion at the elbow (31). This finding was not observed in 44 patients of our study. Instability of the shoulder, radiologic osteoarthritis of the glenohumeral joint and loss of strength during flexion of the elbow joint were not found in any of our patients.

In parallel with the general consensus in the literature, a statistically significant improvement was observed in Constant scores and functional assessments in patients who underwent biceps long head tenotomy.

The major limitation of our study is the retrospective design. However, we consider that our complication rates were lowered by the limited size of the patient population. Prospective controlled studies with a large patient group on the functions of the long head of the biceps tendon, which has become the center of attention in recent years, will provide us with more enlightenment on this subject.

According to the data obtained in our study, we observed that the position of the humeral head in the shoulder joint changed after biceps tenotomy for the treatment of SLAP lesions. We determined that the humeral head migrates superiorly and anteriorly after biceps tenotomy and LHBT stabilizes the humeral head in these vectors. We conclude that the clinical relief of pain and improvement in activities of daily life including shoulder, elbow and forearm movements after tenotomy is a result of the reduction of the traction effect on the biceps labrum complex.

**Conflict of Interest and Financial Status:** Our study has not been financed by an institution and institution. In this study, there is no conflict of interest among the authors on any subject.

**Ethical Approval:** This study was approved by the Aydın Adnan Menderes University Faculty of Medicine Ethics Committee (date: 01.07.2021/E-53043469-050.04.04-47710/protocol number: 2021-105).

**Author contribution:** The authors declare that, they have contributed equally to the manuscript.

## REFERENCES

1. Manske RC, Voight M, Wolfe C, Page P. Long Head of the Biceps Tendon (LHBT). *Int J Sports Phys Ther.* 2022 Dec 2;17(7):1205–7.
2. Khazzam M, George MS, Churchill RS, Kuhn JE. Disorders of the long head of biceps tendon. *J Shoulder Elbow Surg.* 2012 Jan;21(1):136–45.
3. Yu J, Yin Y, Chen W, Mi J. Long Head of the Biceps Tendon Plays a Role in Stress Absorption and Humeral Head Restriction during the Late Cocking and Deceleration Phases of Overhead Throwing: A Finite Element Study. *J Shoulder Elbow Surg.* 2024 Aug 13;S1058-2746(24)00573-1.
4. Diplock B, Hing W, Marks D. The long head of biceps at the shoulder: a scoping review. *BMC Musculoskelet Disord.* 2023 Mar 28;24(1):232.
5. Onyekwelu I, Khatib O, Zuckerman JD, Rokito AS, Kwon YW. The rising incidence of arthroscopic superior labrum anterior and posterior (SLAP) repairs. *J Shoulder Elbow Surg.* 2012 Jun;21(6):728–31.

6. Bey MJ, Elders GJ, Huston LJ, Kuhn JE, Blasler RB, Soslowsky LJ. The mechanism of creation of superior labrum, anterior, and posterior lesions in a dynamic biomechanical model of the shoulder: the role of inferior subluxation. *J Shoulder Elbow Surg.* 1998;7(4):397–401.
7. Huri G, Hyun YS, Garbis NG, McFarland EG. Treatment of superior labrum anterior posterior lesions: a literature review. *Acta Orthop Traumatol Turc.* 2014;48(3):290–7.
8. GOLDING FC. The shoulder--the forgotten joint. *Br J Radiol.* 1962;35(411):149–58.
9. Cetinkaya M, Ataoglu MB, Ozer M, Ayanoglu T, Oner AY, Kanatli U. Do subscapularis tears really result in superior humeral migration? *Acta Orthop Traumatol Turc.* 2018;52(2):109–14.
10. Balke M, Banerjee M, Greshake O, Hoeher J, Bouillon B, Liem D. The Coracohumeral Distance in Shoulders with Traumatic and Degenerative Subscapularis Tendon Tears. *Am J Sports Med.* 2016;44(1):198–201.
11. Dey R, Roche S, Rosch T, Mutsvangwa T, Charilaou J, Sivarasu S. Anatomic variations in glenohumeral joint: an interpopulation study. *JSES Open Access.* 2018;2(1):1–7.
12. Nyffeler RW, Werner CML, Sukthankar A, Schmid MR, Gerber C. Association of a large lateral extension of the acromion with rotator cuff tears. *J Bone Jt Surg - Ser A.* 2006;88(4):800–5.
13. Moor BK, Bouaicha S, Rothenfluh DA, Sukthankar A, Gerber C. Is there an association between the individual anatomy of the scapula and the development of rotator cuff tears or osteoarthritis of the glenohumeral joint? A radiological study of the critical shoulder angle. *Bone Jt J.* 2013;95 B(7):935–41.
14. Weiner DS, Macnab I. Superior migration of the humeral head. A radiological aid in the diagnosis of tears of the rotator cuff. *J Bone Joint Surg Br.* 1970 Aug;52(3):524–7.
15. Hsu SH, Miller SL, Curtis AS. Long head of biceps tendon pathology: management alternatives. *Clin Sports Med.* 2008 Oct;27(4):747–62.
16. Bicos J. Biomechanics and anatomy of the proximal biceps tendon. *Sports Med Arthrosc Rev.* 2008 Sep;16(3):111–7.
17. Molnár S, Hunya Z, Pavlik A, Bozsik A, Shadgan B, Maffulli N. SLAP Lesion and Injury of the Proximal Portion of Long Head of Biceps Tendon in Elite Amateur Wrestlers. *Indian J Orthop.* 2020 May;54(3):310–6.
18. Warner JJ, Bowen MK, Deng X, Torzilli PA, Warren RF. Effect of joint compression on inferior stability of the glenohumeral joint. *J Shoulder Elbow Surg.* 1999;8(1):31–6.
19. Walch G, Edwards TB, Boulahia A, Nové-Josserand L, Neyton L, Szabo I. Arthroscopic tenotomy of the long head of the biceps in the treatment of rotator cuff tears: clinical and radiographic results of 307 cases. *J Shoulder Elbow Surg.* 2005;14(3):238–46.
20. Szabó I, Boileau P, Walch G. The proximal biceps as a pain generator and results of tenotomy. *Sports Med Arthrosc Rev.* 2008 Sep;16(3):180–6.
21. Pagnani MJ, Deng XH, Warren RF, Torzilli PA, Altchek DW. Effect of lesions of the superior portion of the glenoid labrum on glenohumeral translation. *J Bone Joint Surg Am.* 1995 Jul;77(7):1003–10.
22. Pagnani MJ, Deng XH, Warren RF, Torzilli PA, O'Brien SJ. Role of the long head of the biceps brachii in glenohumeral stability: a biomechanical study in cadavera. *J Shoulder Elbow Surg.* 1996;5(4):255–62.
23. Burkart A, Debski R, Musahl V, McMahon P, Woo SLY. [Biomechanical tests for type II SLAP lesions of the shoulder joint before and after arthroscopic repair]. *Orthopade.* 2003 Jul;32(7):600–7.
24. Burkart A, Debski RE, Musahl V, McMahon PJ. Glenohumeral translations are only partially restored after repair of a simulated type II superior labral lesion. *Am J Sports Med.* 2003;31(1):56–63.
25. Leite MJ, Sá MC, Lopes MJ, Matos RM, Sousa AN, Torres JM. Coracohumeral distance and coracoid overlap as predictors of subscapularis and long head of the biceps injuries. *J Shoulder Elbow Surg.* 2019 Sep;28(9):1723–7.
26. Alexander S, Southgate DFL, Bull AMJ, Wallace AL. The role of negative intraarticular pressure and the long head of biceps tendon on passive stability of the glenohumeral joint. *J Shoulder Elbow Surg.* 2013 Jan;22(1):94–101.
27. Gill TJ, McIrvin E, Mair SD, Hawkins RJ. Results of biceps tenotomy for treatment of pathology of the long head of the biceps brachii. *J Shoulder Elbow Surg.* 2001;10(3):247–9.
28. Boileau P, Baqué F, Valerio L, Ahrens P, Chuinard C, Trojani C. Isolated arthroscopic biceps tenotomy or tenodesis improves symptoms in patients with massive irreparable rotator cuff tears. *J Bone Joint Surg Am.* 2007 Apr;89(4):747–57.
29. Carpenter JE, Flanagan CL, Thomopoulos S, Yian EH, Soslowsky LJ. The effects of overuse combined with intrinsic or extrinsic alterations in an animal model of rotator cuff tendinosis. *Am J Sports Med.* 1998;26(6):801–7.
30. Koh KH, Ahn JH, Kim SM, Yoo JC. Treatment of biceps tendon lesions in the setting of rotator cuff tears: prospective cohort study of tenotomy versus tenodesis. *Am J Sports Med.* 2010 Aug;38(8):1584–90.
31. Kelly AM, Drakos MC, Fealy S, Taylor SA, O'Brien SJ. Arthroscopic release of the long head of the biceps tendon: functional outcome and clinical results. *Am J Sports Med.* 2005 Feb;33(2):208–13.