

# Arthroscopic biceps tenodesis: Inlay or onlay technique?

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## ABSTRACT

**BACKGROUND:** The long-term outcomes of arthroscopic tenodesis using the onlay (groove) and inlay (groove) techniques remain debated with respect to tendon healing and graft stability. The aim of our study was to identify the optimal tenodesis strategy by comparing the effects of arthroscopic inlay and onlay techniques on postoperative complication rates, patient satisfaction, and functional recovery.

**METHODS:** Between 2015 and 2021, the treatment outcomes of 54 patients who underwent arthroscopic biceps tenodesis using either the inlay or onlay technique for the management of superior labrum anterior-to-posterior (SLAP) lesions or biceps tendon degeneration were retrospectively evaluated. Patient demographics and clinical variables, including age, sex, side of involvement, follow-up duration, visual analog scale (VAS) score, Constant score, postoperative cramping, and complications, were recorded. Group 1 consisted of 28 patients who underwent inlay tenodesis, while Group 2 included 26 patients who underwent onlay tenodesis.

**RESULTS:** Postoperatively, VAS scores improved substantially in both groups, with no significant difference between Group 1 (0.21±0.45) and Group 2 (0.18±0.37) ( $p=0.789$ ). Similarly, postoperative Constant scores were high in both groups, with Group 1 at 92.73±8.23 and Group 2 at 95.47±5.12; this difference was not statistically significant ( $p=0.145$ ). The mean recovery time was significantly shorter in Group 2 compared to Group 1. Specifically, the mean recovery time was 12.3±4.8 weeks in Group 1 and 8.3±3.72 weeks in Group 2 ( $p=0.01$ ). Cramping was reported in 21.42% of patients in Group 1 and 7.69% in Group 2; however, this difference was not statistically significant ( $p=0.253$ ). In Group 1, Popeye deformity developed in two patients (7.1%), whereas in Group 2 it developed in one patient (3.8%).

**CONCLUSION:** The present study demonstrates that both inlay and onlay arthroscopic biceps tenodesis techniques are effective surgical options for managing biceps tendon degeneration and superior labrum anterior-to-posterior lesions. However, the findings suggest a potential advantage of the onlay technique, as it is associated with faster recovery and a lower risk of complications.

**Keywords:** Arthroscopic biceps tenodesis; inlay technique; onlay technique; interference screw; knotless suture anchor.

## INTRODUCTION

Pathologies of the long head of the biceps tendon are a common source of anterior shoulder pain. In these cases, tendon

inflammation or instability may result in chronic pain that is refractory to conservative treatment. When such symptoms persist, arthroscopic or open biceps tenodesis or tenotomy represents an effective surgical option for symptom control.

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<sup>[1,2]</sup> Particularly in young, active patients, the ability of tenodesis to preserve the anatomical position of the tendon makes it an advantageous technique. However, patient characteristics, expectations, and the risk of complications must be carefully considered when selecting the appropriate surgical approach.<sup>[3,4]</sup>

The purpose of tenodesis is to secure the tendon in a manner that preserves the anatomical length-tension relationship and maintains the normal contour of the biceps muscle.<sup>[5,6]</sup> Recent studies have focused on the surgical approaches and fixation methods used in tenodesis techniques. The biomechanical advantages of suprapectoral, subpectoral, intra-articular, and extra-articular groove-based techniques have been compared using various fixation methods, including interference screws, suture anchors, and cortical button systems.<sup>[1,7,8]</sup>

Arthroscopic biceps tenodesis (ABT) at the proximal bicipital groove has traditionally been performed using the inlay technique, in which the tendon is anchored within a bone socket and fixation is provided by an interference screw.<sup>[9,10]</sup> The use of the onlay technique with a button has also gained popularity in open subpectoral biceps tenodesis.<sup>[11,12]</sup> Subsequently, additional arthroscopic techniques, such as arthroscopic onlay tenodesis, have been introduced.<sup>[13,14]</sup>

The long-term outcomes of arthroscopic tenodesis using the onlay (groove) and inlay (groove) techniques remain debated with regard to tendon healing and graft stability. Although it has been suggested that inlay techniques carry a lower risk of graft migration, this has not been definitively established in randomized studies.<sup>[7,8]</sup> This technical diversity underscores the need for further evidence to determine the optimal surgical protocol.

The aim of this study was to identify the optimal tenodesis strategy by comparing the effects of arthroscopic inlay and onlay techniques on postoperative complication rates, patient satisfaction, functional outcomes, and recovery time.

## MATERIALS AND METHODS

The study was approved by the Acibadem University Medical Research Ethics Committee (2025-06/268) and was conducted in accordance with the principles of the Declaration of Helsinki. Between 2015 and 2021, the outcomes of arthroscopic biceps tenodesis using either the inlay or onlay technique were retrospectively evaluated. These procedures were performed in conjunction with rotator cuff repair in patients with cuff tears (partial tears or <1 cm full-thickness tears) for the management of superior labrum anterior-to-posterior (SLAP) lesions or biceps tendon degeneration. Patients with a follow-up period of less than 12 months, revision or previous shoulder surgery, complete biceps tendon rupture, isolated SLAP lesions, or symptomatic acromioclavicular arthritis were excluded. After applying these criteria, 54 patients met the inclusion criteria and were included in

the study. Patient demographics and clinical variables, including age, sex, side of involvement, follow-up duration, visual analog scale (VAS) score, Constant score, postoperative cramping, and complications, were recorded. Recovery criteria were defined as achieving 160° of forward flexion, 45° of external rotation, and internal rotation to the L3 vertebral level in terms of joint range of motion, a VAS score ≤1, and a Constant score ≥71 (good or very good) at the final follow-up. Measurements were performed by a physiotherapist who was blinded to the surgical technique and who recorded the joint range of motion in the archiving system during patient follow-up. The recovery period was determined by one of the authors, who reviewed the recorded data in the archiving system.

Group 1 consisted of 28 patients (six females, 22 males; 13 left shoulders, 15 right shoulders; 18 with biceps degeneration, 10 with SLAP lesions) who underwent inlay tenodesis. Group 2 included 26 patients (three females, 23 males; seven left shoulders, 19 right shoulders; 18 with biceps degeneration, eight with SLAP lesions) who underwent onlay tenodesis. In Group 1, eight patients had an accompanying partial tear of subscapularis, 10 patients had a small (<1 cm) full-thickness tear of the supraspinatus, and 10 patients had SLAP type II lesions. Group 2 included six patients with an accompanying partial-thickness tear of the subscapularis, 12 with a small (<1 cm) full-thickness tear of the supraspinatus, and eight with a SLAP type II lesion. All partial- and full-thickness tears were repaired. In contrast, patients with SLAP lesions underwent only one of the inlay or onlay tenodesis procedures. Baseline characteristics of the patients are summarized in Table 1.

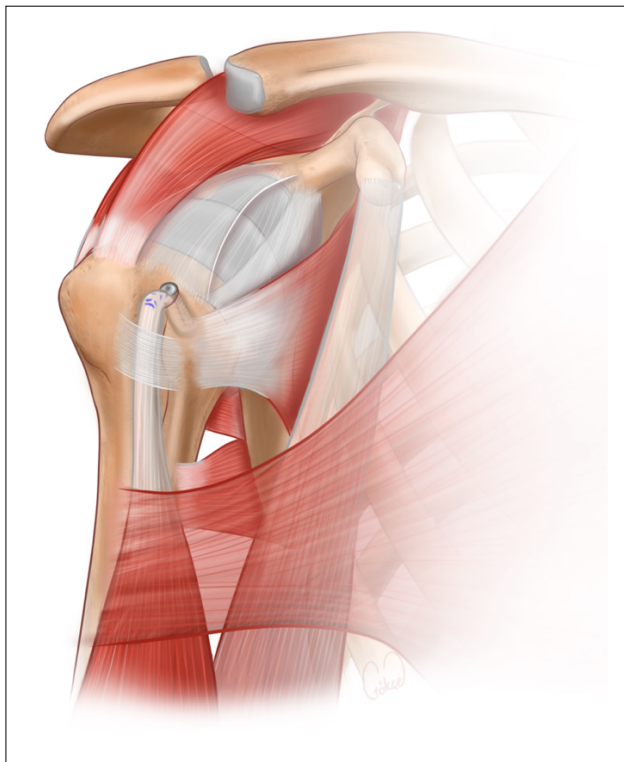
## Surgical Procedure

All surgical procedures were performed arthroscopically by a senior surgeon (A.C.A.) with the patient in the beach-chair position under general anesthesia. A diagnostic glenohumeral

**Table 1.** Baseline patient characteristics

	Inlay (n=28)	Onlay (n=26)	p value
Age, years	48.8 (35-67)	48.52 (14-81)	p>0.05
Sex			
Male	22	23	
Female	6	3	
Side			
Left	13	7	
Right	15	19	
Pathology			
Biceps tendinopathy	18	18	
SLAP	10	8	
Follow-up, months	58.2	60.1	p>0.05

exploration was performed through a standard posterior portal before subacromial exploration and rotator cuff repair. In patients with biceps degeneration or superior labrum anterior-to-posterior lesions, preparation for tenodesis was carried out. For later identification, a No. 2 polypropylene marking suture was placed in the long head of the biceps tendon (LHBT) through the anterosuperolateral portal using a suture passer. The biceps tendon was then released from its origin using arthroscopic scissors and retrieved through the portal. After completion of the glenohumeral joint procedure, the arthroscope was advanced into the subacromial space through the same posterior portal. With the arm in external rotation, the marked biceps tendon was identified and mobilized within the bicipital groove. The superior portion of the transverse humeral ligament was released using radiofrequency. The bony surface of the bicipital groove was prepared, and biceps tenodesis was performed using either the onlay or inlay technique. After removal of the marking suture, the biceps tendon was whipstitched for approximately 30 mm using a No. 2 suture (FiberWire; Arthrex, Inc.) with the Krackow technique. Depending on the tendon size, a 7- or 8-mm interference screw (BioComposite Tenodesis Screw; Arthrex, Inc.) was selected. A socket was then prepared at the anchor site using a reamer 0.5 mm larger than the chosen screw to a depth of 25 mm. The tendon was subsequently docked into the socket and secured with the interference screw (Fig. 1).



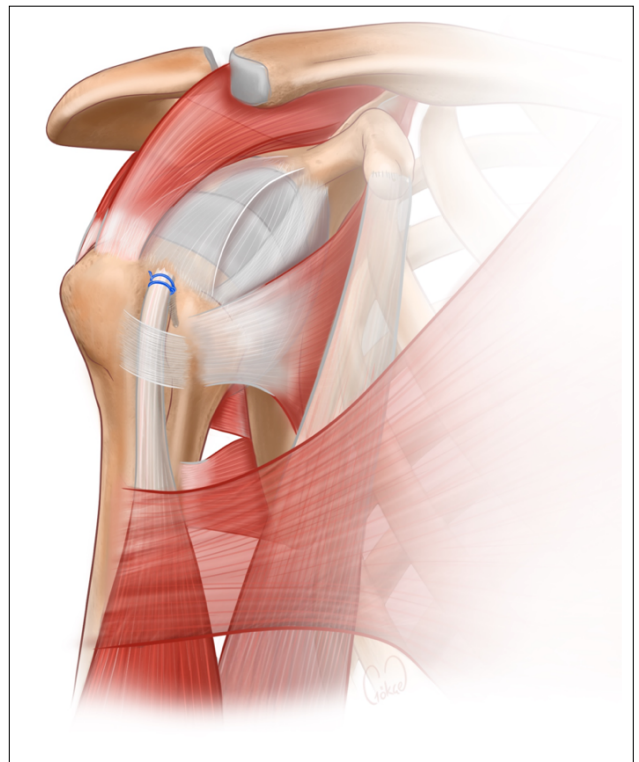
**Figure 1.** Illustration of the inlay technique.

In the onlay technique, once the tendon was exteriorized, the proximal 25 mm along with the marking suture was resected. The remaining tendon was then whipstitched for approximately 30 mm using a No. 2 suture (FiberWire; Arthrex, Inc.) with the Krackow technique. The passed sutures were loaded into a 4.5-mm anchor (PushLock; Arthrex, Inc.), which was inserted into the prepared anchor site, ensuring that no gap remained between the tendon and the anchor bed (Fig. 2).

After completion of the tenodesis, the inflamed bursa was debrided, and acromioplasty was performed when indicated. Subsequently, the rotator cuff tears were repaired according to their specific characteristics. Once all anchors had been placed, a final inspection of both the subacromial space and the glenohumeral joint was performed to ensure proper repair. In the evaluation of treatment outcomes, the inability to visualize the tendon within the intertubercular groove on magnetic resonance imaging (MRI) was defined as failure.

### Rehabilitation

A standard postoperative rehabilitation protocol for arthroscopic rotator cuff repair was applied. Immobilization with an abduction brace was maintained for four weeks in non-massive tears (<3 cm) and for six weeks in massive tears (>3 cm). Active hand, wrist, and elbow movements were initiated immediately after surgery. Following brace removal, active-assisted shoulder range-of-motion exercises were started. Once active-assisted exercises were well tolerated, patients progressed to active range-of-motion (AROM) ex-



**Figure 2.** Illustration of the onlay technique.

ercises. Recovery time was defined as the time required to achieve full, pain-free active range of motion of the shoulder and elbow. Strengthening exercises were initiated at 16–18 weeks postoperatively, and return to sport-specific training was determined on an individual basis after six months.

### Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for macOS, version 26.0.0.0 (IBM Corp., Armonk, NY, USA). Independent samples t-tests were used to compare preoperative and postoperative VAS and Constant scores between the groups, as well as differences in mean recovery time. Fisher's exact test was used to analyze categorical variables, including the incidence of postoperative cramping and the presence of Popeye deformity. A p-value of <0.05 was considered statistically significant.

## RESULTS

A total of 54 patients with a follow-up duration exceeding 12 months were included in the study. Among them, 28 (52%) underwent tenodesis using the inlay technique (Group 1), while 26 (48%) underwent tenodesis using the onlay technique (Group 2).

There were no statistically significant differences between the groups in terms of mean patient age or mean follow-up duration. The mean age was 48.8 years (range: 35–67) in Group 1 and 48.5 years (range: 14–81) in Group 2 ( $p>0.05$ ). Similarly, the mean follow-up duration was 58.2 months (range: 12–82) in Group 1 and 60.1 months (range: 12–73) in Group 2 ( $p>0.05$ ).

Preoperative VAS scores were similar between Group 1 ( $6.09\pm 1.92$ ) and Group 2 ( $5.60\pm 1.14$ ), with no statistically significant difference ( $p=0.256$ ). However, the preoperative Constant score was significantly lower in Group 1 ( $59.56\pm 18.19$ ) compared to Group 2 ( $69.75\pm 6.75$ ) ( $p=0.009$ ). Postoperatively, VAS scores improved substantially in both groups and showed no significant difference between Group 1 ( $0.21\pm 0.45$ ) and Group 2 ( $0.18\pm 0.37$ ) ( $p=0.789$ ). Similarly, postoperative Constant scores were high in both groups, with Group 1 at  $92.73\pm 8.23$  and Group 2 at  $95.47\pm 5.12$ ; this difference was not statistically significant ( $p=0.145$ ).

The mean recovery time was significantly shorter in Group 2 compared to Group 1. Specifically, the mean recovery time was  $12.3\pm 4.8$  weeks in Group 1 and  $8.3\pm 3.72$  weeks in Group 2 ( $p=0.01$ ).

Cramping was reported in 21.42% of patients in Group 1 and 7.69% in Group 2; however, this difference was not statistically significant ( $p=0.253$ ). In Group 1, Popeye deformity developed in two patients (7.1%), whereas in Group 2 it developed in one patient (3.8%). All patients were managed conservatively, and no statistically significant difference was observed between the groups ( $p=1.000$ ). Postoperative outcomes and complications are summarized in Table 2.

**Table 2.** Postoperative outcomes and complications

	Inlay (n=28)	Onlay (n=26)	p value
VAS score			
Preoperative	6.09±1.92	5.6±1.14	0.256
Postoperative	0.21±0.45	0.18±0.37	0.789
Constant score			
Preoperative	59.56±18.19	69.75±6.75	0.009
Postoperative	92.73±8.23	95.47±5.12	0.145
Postoperative complications			
Cramping (%)	21.4	7.7	0.253
Popeye deformity (%)	7.1	3.8	1.000
Mean recovery time (weeks)	12.3±4.8	8.3±3.7	0.001

In Group 1, one patient required surgical intervention due to screw pullout, and another patient from the same group underwent four aspirations because of recurrent hematoma.

## DISCUSSION

Several techniques exist for the long head of the biceps tendon tenodesis. Key factors in selecting a tenodesis technique include the fixation site (subpectoral or suprapectoral, either in the subacromial space within the bicapital groove or in the intra-articular region) and the fixation method (onlay or inlay). The choice of fixation site also determines the surgical approach, which may be arthroscopic, open, or a hybrid procedure. Although no single method has been shown to be universally superior with regard to fixation technique or site, the optimal approach for each patient should be determined based on factors such as activity level, surgeon experience, and the presence of concomitant shoulder pathologies.<sup>[15,16]</sup> Each tenodesis technique presents specific advantages and limitations. For instance, the subpectoral approach allows removal of more diseased tissue and may reduce the risk of persistent pain, but it carries a slightly increased risk of humeral fracture.<sup>[17-19]</sup> Arthroscopic approaches are less invasive and allow comprehensive evaluation of the joint, although fixation is generally biomechanically weaker.<sup>[20]</sup> Regardless of the chosen method, proper tensioning and secure fixation are essential for long-term success.

The arthroscopic suprapectoral (intra-groove) tenodesis technique used in our study is increasingly favored because it allows simultaneous treatment of intra-articular pathologies and typically provides effective pain relief with low complication rates, demonstrating outcomes comparable to those of open subpectoral tenodesis.<sup>[16,21]</sup> Early functional recovery and patient-reported outcomes may also be superior with the arthroscopic approach.<sup>[21]</sup>

Another topic of debate in the literature is the optimal fixa-

tion method. There is no consensus regarding the superiority of inlay or onlay tenodesis.<sup>[22]</sup> The inlay tenodesis technique provides strong biomechanical fixation by positioning the tendon within the bone during the early postoperative period.<sup>[23]</sup> In fact, it has been reported that load-to-failure values comparable to those obtained with the inlay technique can be achieved by the end of the third week in onlay tenodesis procedures.<sup>[24]</sup> However, the widespread clinical use of onlay tenodesis techniques and the reporting of successful outcomes represent a relatively recent development.<sup>[22,25]</sup> On the other hand, inlay tenodesis is associated with increased surgical complexity, longer operative times, a higher risk of humeral fracture, and potential complications such as Popeye deformity if fixation or tensioning is inadequate or excessive.<sup>[23]</sup> In contrast, the onlay technique was developed to address some of these limitations, particularly in arthroscopic procedures. By securing the tendon onto the bone surface using knotless anchor systems or all-suture anchor systems, this method is less invasive, technically simpler, and may enable faster rehabilitation.<sup>[26]</sup> Although the biomechanical strength of onlay fixation may be slightly lower than that of inlay techniques, advances in suture methods have minimized the risk of tendon slippage, making it a reliable alternative with favorable patient outcomes.<sup>[26]</sup>

The aim of this study was to determine the most suitable tenodesis fixation technique by comparing the effects of arthroscopic suprapectoral biceps tenodesis using the inlay and onlay techniques on postoperative complications, patient satisfaction, and functional recovery.

Both inlay and onlay arthroscopic biceps tenodesis techniques have been shown in the literature to yield significant clinical improvements.<sup>[6,25,27,28]</sup> As mentioned above, complications are rare and may include persistent pain, fixation failure, Popeye deformity, or ongoing muscle tenderness. Consistent with these findings, our study also demonstrated postoperative improvement in outcome scores in both groups. However, although the incidence of cramping and Popeye deformity was proportionally higher in the inlay group, the difference did not reach statistical significance ( $p=0.253$  and  $p=1.000$ , respectively). Although the difference observed in our study was not statistically significant with respect to Popeye deformity, Jackson et al.<sup>[22]</sup> reported that onlay tenodesis resulted in significantly less Popeye deformity than inlay tenodesis [7.80% in the onlay group versus 11.28% in the inlay group ( $p=0.07$ )]. Similarly, another study reported a rate of Popeye deformity of 9.4% in the onlay group and 27% in the inlay group.<sup>[6]</sup> We believe that Popeye deformity may be related to the mechanical interaction between the interference screw and the tendon during fixation. Specifically, as the screw is advanced into the bone socket, its threads may shear or compromise tendon integrity, potentially increasing the risk of tendon slippage or failure over time.<sup>[6,18]</sup>

When evaluated in terms of revision rates, the onlay technique has been reported to result in a lower rate of revision

compared to the inlay technique.<sup>[29]</sup> In line with the findings of Cook et al.,<sup>[29]</sup> revision surgery was not required in the onlay group in our study. However, in the inlay group, revision surgery was required in one patient due to screw pullout.

In the literature, comparisons between onlay and inlay techniques have not been performed using a clearly defined recovery time. In our study, recovery time was defined as the point at which the patient achieved full, pain-free active range of motion of the shoulder and elbow. Using this definition, the onlay technique was associated with significantly faster recovery compared to the inlay technique ( $p=0.001$ ). This finding is supported by Park et al.,<sup>[28]</sup> who reported that the inlay technique was associated with a slower recovery profile. As previously mentioned, existing literature has generally emphasized secondary outcomes, such as complication rates and functional scores, rather than directly comparing recovery timelines.<sup>[6,30-32]</sup> Although several studies have highlighted certain technical advantages of the onlay approach, a clear consensus regarding its superiority in terms of recovery speed remains limited. To the best of our knowledge, this study is the first to indicate that while both inlay and onlay tenodesis techniques yield favorable outcomes, onlay tenodesis enables faster recovery.

The main limitation of our study is its retrospective design, which may introduce selection bias and limit the ability to control for confounding variables. Additionally, the patients included in this study did not have isolated biceps pathology but had concomitant rotator cuff tears. Nevertheless, complications such as anterior shoulder cramping and Popeye deformity may be considered specific complications of biceps tenodesis. The heterogeneity of the groups in terms of accompanying pathologies may also be considered a limitation of the study. However, both groups consisted of patients with a similar number of associated pathologies, and since this study is the first to evaluate recovery time as an outcome measure, it may provide useful insights for clinical practice. Finally, the study included cases of both degenerative biceps pathology and SLAP lesions. As these two conditions may differ in terms of healing potential and postoperative outcomes, this factor could have influenced the study results. However, the similar number of patients with SLAP lesions in both groups mitigates this limitation. Further prospective, randomized controlled trials are warranted to validate these findings and more accurately assess the comparative efficacy of inlay and onlay biceps tenodesis techniques.

## CONCLUSION

This study demonstrates that both inlay and onlay arthroscopic biceps tenodesis are effective surgical approaches for the treatment of biceps tendon degeneration and superior labrum anterior-to-posterior lesions. However, the findings indicate a potential advantage of the onlay technique, as it is associated with faster recovery and a lower risk of complications.

**Ethics Committee Approval:** This study was approved by the Acibadem University Medical Research Ethics Committee Ethics Committee (Date: 17.04.2025, Decision No: 2025-06/268).

**Peer-review:** Externally peer-reviewed.

**Authorship Contributions:** Concept: G.K., O.T., Y.E.Ö., S.K.D., Y.B.T., A.C.A.; Design: G.K., O.T., Y.E.Ö., S.K.D., Y.B.T., A.C.A.; Supervision: G.K., O.T., Y.E.Ö., S.K.D., Y.B.T., A.C.A.; Resource: G.K., O.T., Y.E.Ö., S.K.D., Y.B.T., A.C.A.; Materials: G.K., O.T., Y.E.Ö., S.K.D., Y.B.T., A.C.A.; Data collection and/or processing: G.K., O.T., Y.E.Ö., S.K.D., Y.B.T., A.C.A.; Analysis and/or interpretation: G.K., O.T., Y.E.Ö., A.C.A.; Literature review: G.K., O.T., Y.E.Ö.; Writing: G.K., Y.E.Ö.; Critical review: G.K., O.T., A.C.A.

**Conflict of Interest:** None declared.

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## ORJİNAL ÇALIŞMA - ÖZ

### Artroskopik biceps tenodezi: Inlay mi, onlay mı?

**AMAÇ:** Artroskopik onlay ve inlay teknikleri kullanarak yapılan tenodezin uzun dönem sonuçları, tendon iyileşmesi ve greft stabilitesi açısından tartışmalıdır. Çalışmamızın amacı, artroskopik inlay ve onlay tekniklerinin postoperatif komplikasyon oranları, hasta memnuniyeti ve fonksiyonel iyileşme üzerindeki etkilerini karşılaştırarak optimal tenodez stratejisini belirlemektir.

**GEREÇ VE YÖNTEM:** 2015–2021 yılları arasında, superior labrum anterior-posterior (SLAP) lezyonları veya biceps tendon dejenerasyonu tedavisinde inlay veya onlay tekniği ile artroskopik biceps tenodezi uygulanan 54 hastanın tedavi sonuçları retrospektif olarak değerlendirildi. Hastaların demografik ve klinik verileri; yaş, cinsiyet, etkilenen taraf, takip süresi, görsel analog skala (VAS) ve Constant skorları, postoperatif kramplar ve komplikasyonlar kaydedildi. Grup 1, inlay tenodezi yapılan 28 hastadan; Grup 2 ise onlay tenodezi yapılan 26 hastadan oluştu.

**BULGULAR:** Postoperatif dönemde, her iki grupta VAS skorları belirgin şekilde iyileşti ve Grup 1 ( $0.21 \pm 0.45$ ) ile Grup 2 ( $0.18 \pm 0.37$ ) arasında anlamlı fark bulunmadı ( $p=0.789$ ). Benzer şekilde, postoperatif Constant skorları her iki grupta yüksek bulundu; Grup 1'de  $92.73 \pm 8.23$ , Grup 2'de  $95.47 \pm 5.12$  idi ve bu fark istatistiksel olarak anlamlı değildi ( $p=0.145$ ). Ortalama iyileşme süresi, Grup 2'de Grup 1'e göre anlamlı şekilde daha kısaydı; Grup 1'de  $12.3 \pm 4.8$  hafta, Grup 2'de  $8.3 \pm 3.72$  hafta ( $p=0.01$ ). Kramplar, Grup 1'de hastaların %21.42'sinde, Grup 2'de %7.69'unda rapor edildi; ancak bu fark istatistiksel olarak anlamlı değildi ( $p=0.253$ ). Grup 1'de 2 hastada (%7.1) popeye deformitesi gelişirken, Grup 2'de 1 hastada (%3.8) ortaya çıktı.

**SONUÇ:** Bu çalışma, hem inlay hem de onlay artroskopik biceps tenodezi tekniklerinin biceps tendon dejenerasyonu ve SLAP lezyonlarının yönetiminde etkili cerrahi seçenekler olduğunu göstermektedir. Ancak karşılaştırmalı analizimiz, onlay tekniğinin daha kısa iyileşme süreleri ve daha düşük komplikasyon oranı ile klinik bir avantaj sağlayabileceğini önermektedir.

**Anahtar sözcükler:** Artroskopik biceps tenodezi; düğümsüz sütür akor; inlay tekniği; interferans vidası; onlay tekniği.

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