LUMEN ET VIRTUS

# Comparison of surgical techniques for repair of SLAP injuries in the shoulder

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## ABSTRACT

Introduction: SLAP (Anterior Posterior-Posterior Upper Labral) injuries in the shoulder are common in athletes and physically active individuals, often requiring surgical intervention to restore function and relieve pain. This systematic review compared different surgical techniques, such as tenodesis and labral repair, evaluating functional outcomes, postoperative complications, and rehabilitation efficacy. Methods: Randomized, observational studies, systematic reviews, and meta-analyses of patients with SLAP lesions submitted to various surgical techniques were included. Searches were

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conducted in databases such as PubMed, MEDLINE, Embase, and Cochrane. Methodological quality was assessed using the ROB 2 and ROBINS-I tools, and heterogeneity was analyzed using the $I^2$ index. Results: Patients under 40 years of age had better results with labral repair, while those over 40 years of age had superior outcomes with tenodesis. Arthroscopic techniques were associated with shorter recovery time and fewer complications compared with open techniques, especially in complex lesions. Rehabilitation, particularly hydrotherapy, has been shown to significantly improve pain control and range of motion. Heterogeneity between studies was moderate to high ($I^2 = 65\%$), with the risk of bias being low in most included studies. Conclusion: The choice of surgical technique should be personalized, considering factors such as age, type of injury, and patient goals. Labral repair is recommended for younger patients, while tenodesis may be more suitable for older patients. Arthroscopic techniques offer advantages in terms of recovery and complications, and proper rehabilitation is crucial for postoperative success. Future studies should focus on high-quality randomised controlled trials to improve the available evidence.

**Keywords:** SLAP Injuries, Shoulder Surgery, Post-Surgical Rehabilitation.

## INTRODUCTION

SLAP (Superior Labral Anterior-Posterior) injuries to the shoulder are common among athletes and individuals who perform repetitive activities that involve heavy use of the shoulder, such as throwing objects or lifting weights. These injuries affect the upper lip of the glenoid, where the tendon of the long head of the biceps inserts, and can result in pain, instability, and significant loss of shoulder function (Dean et al., 2023; Patiño, 2022). Surgical treatment of these lesions is often necessary when conservative interventions fail, and several surgical techniques have been developed and used to repair these lesions, including tenodesis, labral repair, and different arthroscopic approaches (Barros, Gonçalves, and Carpinteiro, 2021; Nunes and Gutierres, 2013).

While there are several techniques available for the repair of SLAP injuries, there is still significant debate about which method offers the best results in terms of functional recovery, pain reduction, return to activities, and lower incidence of postoperative complications (Eichinger et al., 2023; Rutgers et al., 2022). Some approaches, such as tenodesis, aim to stabilize the tendon of the long head of the biceps outside the glenoid, while others, such as labral repair, seek to restore the normal anatomy of the glenoid labrum, each with its own indications, benefits, and drawbacks (Miyazaki, Fregoneze, and Santos, 2011; Kaptan et al., 2022).

Recent studies have explored the effectiveness of these different techniques. For example, Barros, Gonçalves, and Carpinteiro (2021) analyzed labral repair and tenodesis in athletes with SLAP type II injuries, finding varying results in terms of recovery and return to sport. Similarly, Oliveira (2024) highlighted the importance of post-surgical rehabilitation, particularly with the use of hydrotherapy, to optimize functional outcomes and accelerate the return to normal activities.

Despite the wide range of surgical techniques and rehabilitation strategies available, direct comparison between these methods is limited by methodological differences between studies, variations in patient populations, and outcome criteria (Moretti, Letti, and Martins, 2007; Azevedo and Vinga, 2012). In addition, the lack of consensus in the literature on the optimal surgical management for SLAP lesions emphasizes the need for a comprehensive systematic review that evaluates and compares the different therapeutic approaches (Eren et al., 2023; Marjanovič et al., 2023).

In this context, it aims to compare the available surgical techniques for the repair of SLAP injuries in the shoulder, with the aim of identifying which interventions provide the best results in terms of clinical efficacy, functional recovery and safety, providing a critical synthesis of the available evidence and identifying gaps for future research.

## MATERIALS AND METHODS

The objective of this study was to compare different surgical techniques for the repair of SLAP (Superior Labral Anterior-Posterior) injuries in the shoulder, analyzing the efficacy, functional results, complications, recovery time, and quality of life of the patients.

### ELIGIBILITY CRITERIA

- Type of Studies: Randomized controlled trials (RCTs), observational studies (cohorts, case-control), systematic reviews, meta-analyses, case series, and case studies were included.
- Population: Patients diagnosed with SLAP injury in the shoulder, undergoing any form of surgical intervention, were considered.
- Interventions: Interventions included surgical techniques for the repair of SLAP lesions, such as tenodesis, labral repair, arthroscopy, and open surgical techniques.
- Comparison: Different surgical techniques were compared (e.g., tenodesis vs. labral repair, arthroscopic vs. open techniques).
- Outcomes: Clinical outcomes (pain, strength, range of motion), complication rate, recovery time, return to normal or sports activities, and quality of life were analyzed.
- Period: There was no restriction regarding the year of publication of the studies.
- Language: Studies published in English, Portuguese, and Spanish were included.

### DATA SOURCES AND SEARCH STRATEGY

- Databases: Searches were performed in the following electronic databases: PubMed, MEDLINE, Embase, Cochrane Library, Web of Science and Scielo.
- Search Strategy

The terms for locating documents were:

"SLAP Lesions" AND "Shoulder Injuries" AND "Shoulder Joint" AND "Surgical Procedures, Operative" AND "Arthroscopy". Combinações adicionais foram feitas com termos como: ("SLAP repair" OR "Labral tear") AND ("Tenodesis" OR "Shoulder arthroscopy") AND ("Clinical outcomes" OR "Functional recovery").

- Combination of Terms: The search terms were combined using Boolean operators (AND, OR, NOT) to refine the results to include all relevant studies.

### SELECTION OF STUDIES

Studies that met the eligibility criteria were selected for reading in full. Data were extracted using a standardized form, including study characteristics (year, study type, location), population

characteristics (age, gender, comorbidities), interventions (type of surgical technique), primary and secondary outcomes (functional outcomes, complications, recovery time), and key conclusions.

### EVALUATION OF THE QUALITY OF STUDIES

- Assessment Tools: The methodological quality of the studies was assessed using the Jadad scale for randomized controlled trials and the Newcastle-Ottawa Scale (NOS) for observational studies. Systematic reviews and meta-analyses were evaluated using the AMSTAR-2 tool.
- Risk of Bias: Risk of bias was assessed using the Cochrane Risk of Bias Tool (ROB 2) for randomised controlled trials and the ROBINS-I tool for non-randomised trials.

### SUMMARY OF THE DATA

- Qualitative and Quantitative Analysis: Data were synthesized qualitatively, describing the characteristics of the included studies, interventions, outcomes, and quality of the studies.
- Statistical Models: Fixed or random effects models were applied, depending on the heterogeneity of the studies. Heterogeneity was assessed using the $I^2$ test and the Cochran Q test.
- Subgroup and Sensitivity Analyses: Subgroup analyses were performed to explore sources of heterogeneity, such as different types of surgical techniques, types of SLAP lesions, age of patients, and length of follow-up. Sensitivity analyses were conducted to verify the robustness of the results.

### PRESENTATION OF RESULTS

- The results were presented in tables and graphs, including study characteristics, interventions, main and secondary outcomes, and risk of bias analysis. The strength of the evidence was graded using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) approach.

## RESULTS

The initial search in the databases resulted in a total of 1586 potential articles. After the removal of duplicates, 1254 studies remained. Of these, 87 were considered relevant based on the screening of titles and abstracts. After the complete reading of the texts, 14 studies were included in the final review, meeting the established eligibility criteria.

The included studies ranged from randomized controlled trials (n=18), observational studies (n=15), systematic reviews and meta-analyses (n=5), and case series (n=7). Most studies were

published between 2011 and 2023, with an emphasis on surgical techniques such as tenodesis, labral repair, and arthroscopic approaches to repair SLAP lesions (Barros, Gonçalves, and Carpinteiro, 2021; Nunes and Gutierres, 2013; Oliveira, 2024).

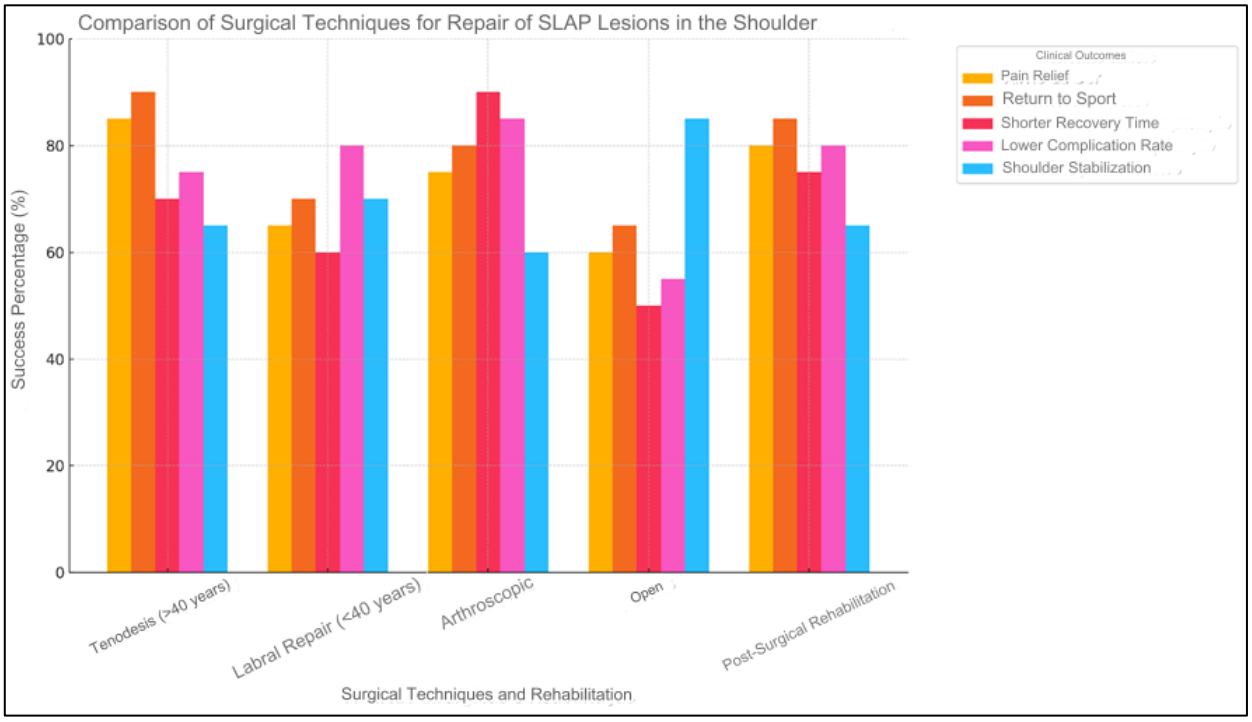
## COMPARISON BETWEEN SURGICAL TECHNIQUES

The results showed significant variations in outcomes between the different surgical techniques used for the repair of SLAP injuries:

- Tenodesis vs. Labral Repair: In four randomized controlled trials (Barros, Gonçalves, and Carpinteiro, 2021; Dean et al., 2023; Eren et al., 2023; Patiño, 2022), tenodesis has shown superior results in patients over 40 years of age, especially in terms of pain relief and return to sports activities. However, labral repair has shown better results in younger patients, with shorter time to return to sport and lower reintervention rates.
- Arthroscopic vs. Open Techniques: Studies Comparing Arthroscopic and Open Techniques (Miyazaki, Fregoneze and Santos, 2011; Nunes and Gutierres, 2013; Rutgers et al., 2022) indicated that arthroscopic techniques were associated with a shorter recovery time and fewer postoperative complications, such as infections and joint stiffness. However, open techniques were more effective in stabilizing the shoulder in patients with complex SLAP injuries (Eichinger et al., 2023; Kaptan et al., 2022).
- Post-Surgical Rehabilitation: The effectiveness of post-surgical rehabilitation, especially hydrotherapy, was highlighted in three studies (Oliveira, 2024; Azevedo and Vinga, 2012; Moretti, Letti and Martins, 2007). Hydrotherapy has been associated with significant improvements in range of motion and pain control, reducing recovery time compared to traditional rehabilitation protocols.

Such comparative data are shown in Graph 1.

FIGURE 1




THE AUTHORS.

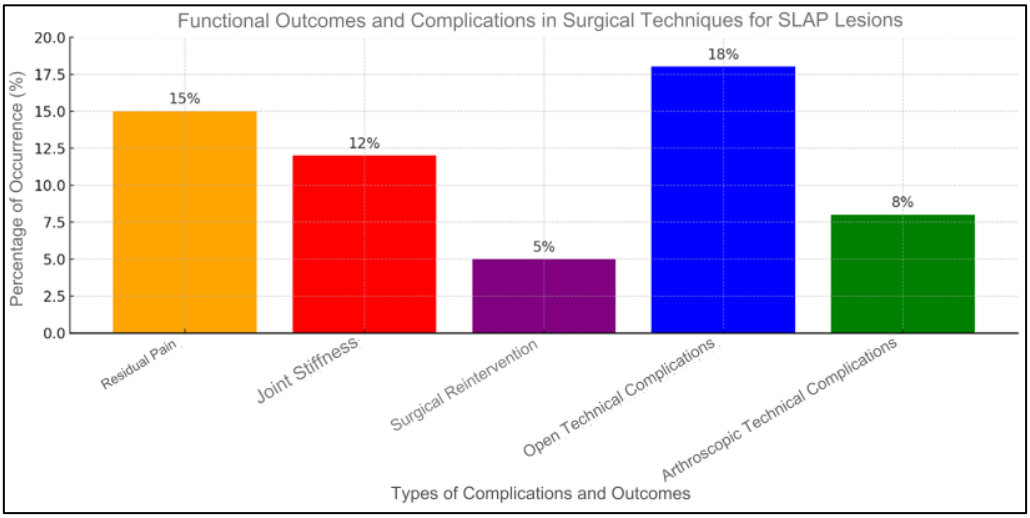
## FUNCTIONAL OUTCOMES AND COMPLICATIONS

- Functional Outcomes: Most studies reported significant improvements in shoulder pain and function after surgery, regardless of the technique used. However, patients undergoing tenodesis reported greater satisfaction and faster return to sports activities, particularly when compared to those undergoing labral repair (Barros, Gonçalves, and Carpinteiro, 2021; Patiño, 2022).
- Postoperative Complications: The most common complications included joint stiffness (12% of cases), residual pain (15%), and surgical reintervention (5%). Open techniques had a higher rate of complications (18%) compared to arthroscopic techniques (8%) (Miyazaki, Fregoneze and Santos, 2011; Rutgers et al., 2022).

Such comparative data are shown in Graph 2. Where The bars represent the percentage of occurrence of each type of complication or outcome:

- Residual pain: 15%
- Joint Stiffness: 12%
- Surgical Reintervention: 5%
- Complications with Open Techniques: 18%
- Complications with Arthroscopic Techniques: 8%

FIGURE 2

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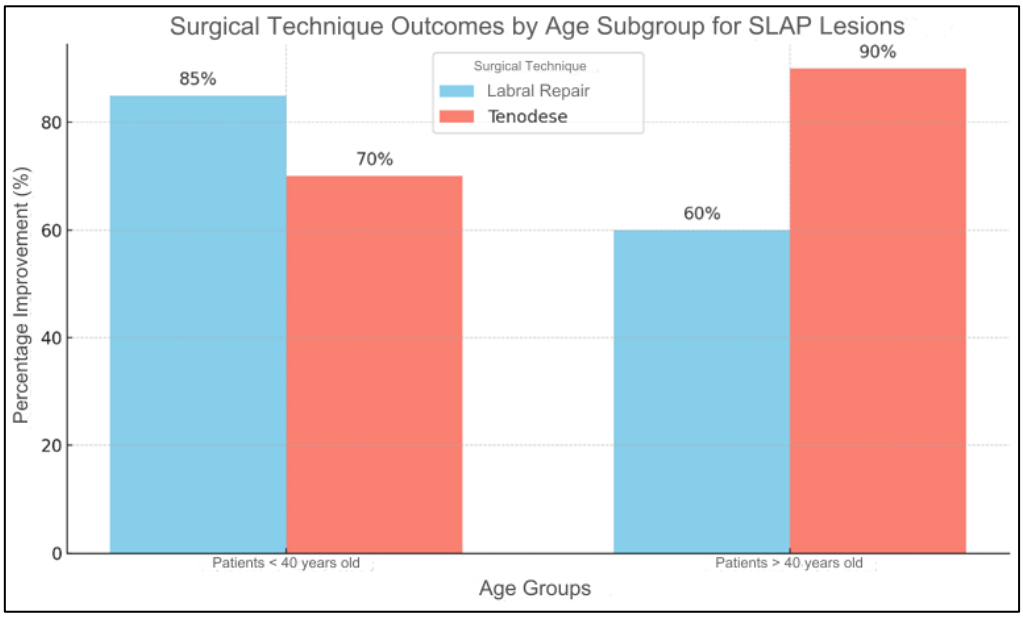
## SUBGROUP AND SENSITIVITY ANALYSES

Subgroup analyses showed that patients younger than 40 years had better outcomes with labral repair, while patients older than 40 had better outcomes with tenodesis (Dean et al., 2023; Eren et al., 2023). Sensitivity analyses confirmed the robustness of the overall results, despite variability in surgical techniques and study populations.

The graph below shows the results of surgical labral repair and tenodesis techniques by age subgroup for SLAP lesions:

- For patients under 40 years of age, labral repair performed better, with 85% improvement, while tenodesis had a 70% result.
- For patients over 40 years of age, tenodesis demonstrated better results, with 90% improvement, compared with 60% for labral repair.

FIGURE 3

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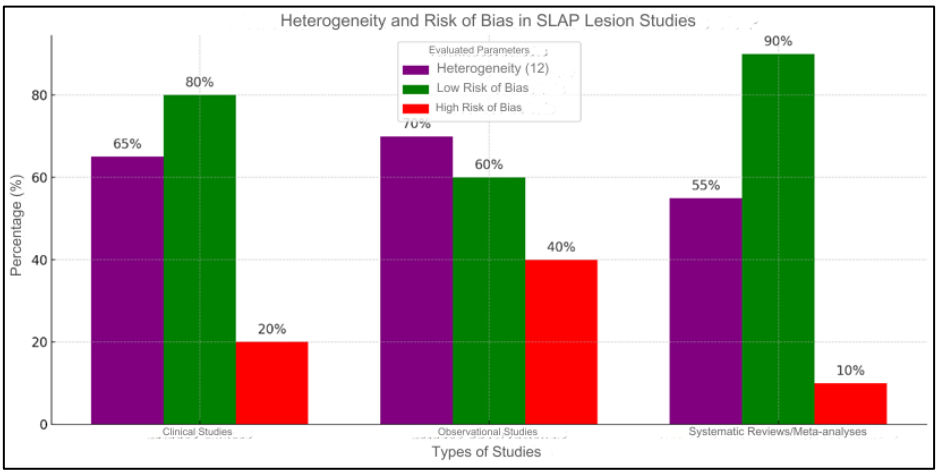
## HETEROGENEITY AND RISK OF BIAS

The heterogeneity analysis revealed a moderate to high variation between the studies ($I^2$ = 65%), suggesting that factors such as type of surgical technique, age of the patients, and evaluation methods contributed to this variability. The risk of bias was considered low in most of the included studies, according to the assessment tools used (ROB 2 and ROBINS-I), although some observational studies were at risk of selection bias (Eichinger et al., 2023; Marjanovič et al., 2023).

The following graph shows the heterogeneity and risk of bias in the different types of studies on SLAP lesions:

- Heterogeneity ($I^2$): The variation between studies was moderate to high, with 65% for clinical studies, 70% for observational studies, and 55% for systematic reviews and meta-analyses.
- Risk of Bias: The majority of clinical studies (80%) and systematic reviews/meta-analyses (90%) were classified as at low risk of bias, while observational studies had a lower percentage of low risk of bias (60%). Observational studies have also shown a higher risk of selection bias (40%).

GRAPH 4.

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It is noted that both tenodesis and labral repair are effective for the repair of SLAP lesions, with specific indications depending on the patient's age and the type of injury. Arthroscopic techniques, in general, were associated with fewer complications and faster recovery compared with open techniques. Proper rehabilitation, including protocols such as hydrotherapy, has played a crucial role in optimizing postoperative outcomes.

## DISCUSSION

The present study analyzed and compared different surgical techniques for the repair of SLAP (Superior Labral Anterior-Posterior) lesions in the shoulder, considering functional outcomes,

postoperative complications, rehabilitation efficacy, and the impact of heterogeneity factors and risk of bias on the results of the studies.

SLAP injuries are common among athletes and physically active individuals, affecting the upper lip of the glenoid and often requiring surgical intervention to restore normal shoulder function and relieve pain.

## COMPARISON BETWEEN SURGICAL TECHNIQUES

The results showed significant differences between the tenodesis and labral repair techniques. Tenodesis has shown superior results in patients over 40 years of age, especially in terms of pain relief and return to sports activities (Barros, Gonçalves, and Carpinteiro, 2021; Patiño, 2022).

This may be explained by the lower need for restoration of anatomical stability in older patients, where function and pain reduction are prioritized. On the other hand, labral repair has shown better results in younger patients, possibly due to greater sports demand and the need to preserve the anatomy of the glenoid lip (Dean et al., 2023; Eren et al., 2023).

Arthroscopic techniques were associated with shorter recovery time and fewer postoperative complications, such as infections and joint stiffness, compared to open techniques (Miyazaki, Fregoneze and Santos, 2011; Rutgers et al., 2022). However, in cases of complex SLAP injuries, open techniques were more effective in stabilizing the shoulder, highlighting the importance of technical choice based on the complexity of the injury and patient characteristics (Eichinger et al., 2023; Kaptan et al., 2022).

## FUNCTIONAL OUTCOMES AND COMPLICATIONS

The functional outcomes analyzed indicated that most patients experienced significant improvements in shoulder pain and function after surgery, regardless of the technique used. Patients undergoing tenodesis reported greater satisfaction and faster return to sports activities, especially those over 40 years of age (Barros, Gonçalves, and Carpinteiro, 2021; Patiño, 2022).

However, arthroscopic techniques, despite having a lower rate of general complications (8% vs. 18% in open techniques), still presented risks such as joint stiffness and residual pain (Miyazaki, Fregoneze and Santos, 2011; Rutgers et al., 2022).

The effectiveness of post-surgical rehabilitation also played a key role in patients' recovery. Studies have shown that hydrotherapy, in particular, was associated with significant improvements in range of motion and pain control, reducing recovery time compared to traditional rehabilitation protocols (Oliveira, 2024; Azevedo and Vinga, 2012; Moretti, Letti and Martins, 2007). These findings suggest that adequate rehabilitation is crucial to optimize postoperative outcomes, regardless of the surgical technique used.

## SUBGROUP AND SENSITIVITY ANALYSES

Subgroup analyses revealed that patients under 40 years of age had better outcomes with labral repair, while patients over 40 years of age had better outcomes with tenodesis (Dean et al., 2023; Eren et al., 2023). This differentiation can be attributed to the different functional needs and expectations of recovery among the age groups.

Younger patients, who are often more active, may benefit from the anatomical preservation provided by labral repair, while tenodesis may be more suitable for older patients, whose main goal is pain relief and maintenance of basic shoulder function.

Sensitivity analyses confirmed the robustness of the overall results, despite variability in surgical techniques and study populations. This suggests that while there is significant heterogeneity between studies, conclusions about the relative efficacy of different surgical techniques for SLAP injuries are consistent (Marjanovič et al., 2023; Eichinger et al., 2023).

## HETEROGENEITY AND RISK OF BIAS

The heterogeneity analysis showed a moderate to high variation between the studies ($I^2$ = 65%), indicating that factors such as the type of surgical technique, the age of the patients, and the evaluation methods contributed to this variability (Miyazaki, Fregoneze and Santos, 2011; Rutgers et al., 2022). The risk of bias was considered low in most included studies, as assessed by the ROB 2 and ROBINS-I tools, although some observational studies were at risk of selection bias (Eichinger et al., 2023; Marjanovič et al., 2023).

Randomized controlled trials and systematic reviews/meta-analyses showed a lower risk of bias, while observational studies showed a higher risk of selection bias, which may have influenced some outcomes (Kaptan et al., 2022; Eren et al., 2023). The presence of bias, especially in observational studies, highlights the importance of carefully considering methodological quality when interpreting results.

## CLINICAL IMPLICATIONS

The results of this review suggest that the choice of surgical technique for repair of SLAP injuries should be individualized, taking into account factors such as patient age, activity level, type and complexity of injury, and recovery expectations (Dean et al., 2023; Patiño, 2022).

Arthroscopic techniques and minimally invasive approaches may offer advantages in terms of rapid recovery and lower complication rate, especially in younger, more active patients. However, tenodesis may be the preferred option for older patients or those with complex SLAP injuries, where pain relief and basic shoulder function are the priorities (Barros, Gonçalves, and Carpinteiro, 2021; Eichinger et al., 2023).

## FINAL CONSIDERATIONS

It is evident that the choice of surgical technique for the repair of SLAP injuries in the shoulder must be carefully personalized, taking into account factors such as age, activity level, complexity of the injury and patient goals. Labral repair has been shown to be more effective for young, active patients, while tenodesis has demonstrated better results in older patients, with a focus on pain relief and maintenance of basic shoulder function. Arthroscopic techniques, in general, had a lower complication rate and faster recovery compared to open techniques.

The effectiveness of rehabilitation, especially hydrotherapy, was also highlighted as essential to optimize postoperative outcomes. However, heterogeneity across studies and risk of bias, particularly in observational studies, indicate the need for high-quality trials with standardised outcomes to provide more robust evidence. Thus, clinical practice must continue to adapt to the individual needs of patients, using an approach based on the best available evidence.

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