

# Excellent Clinical and Radiological Midterm Outcomes for the Management of Recurrent Anterior Shoulder Instability by All-Arthroscopic Modified Eden-Hybinette Procedure Using Iliac Crest Autograft and Double-Pair Button Fixation System: 3-Year Clinical Case Series With No Loss to Follow-Up



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**Purpose:** To evaluate the clinical, functional, and radiological midterm outcomes of the all-arthroscopic modified Eden-Hybinette procedure in patients with recurrent anterior shoulder instability. **Methods:** A retrospective, single-center case series with prospectively collected data was conducted. The inclusion criterion was traumatic recurrent anterior shoulder instability with significant glenoid bone loss; patients with atraumatic or multidirectional instability were excluded. An all-arthroscopic modified Eden-Hybinette procedure using iliac crest autograft and double-pair button fixation was carried out. All patients were postoperatively assessed for recurrence and apprehension. Shoulder range of motion values and functional scores, including American Shoulder and Elbow Surgeons Score, Oxford instability, Rowe instability, and Walch-Duplay, were recorded. Graft positions, healing, and absorption were evaluated with computed tomography. Comparisons of values were performed with paired *t* tests for normally distributed differences and with nonparametric Wilcoxon's signed rank test otherwise. **Results:** The final study cohort included 28 patients, mean age  $36 \pm 10$  years, and mean follow-up period  $43 \pm 6$  months (range 36 to 53). Median glenoid bone loss was 12.4% (range 8% to 33%). No recurrence occurred, no subjective shoulder instability was reported, and no major complications were documented through the last follow-up. Postoperative shoulder range of motion had no significant differences compared with the healthy side. All final postoperative functional scores significantly increased to show excellent results compared with preoperative values. All grafts were positioned and healed optimally, and none was completely reabsorbed. **Conclusions:** The all-arthroscopic modified Eden-Hybinette procedure is safe, leading to excellent clinical and radiological midterm outcomes in patients with recurrent anterior shoulder instability. This technique restores glenoid bone defects and preserves the normal shoulder anatomy. **Level of Evidence:** IV, therapeutic, retrospective case series

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In traumatic anterior shoulder dislocations, the rate of recurrence can be high, and various factors have been implicated in increasing the risk of redislocations.<sup>1,2</sup> These factors include patient age, male sex, and participation in contact and overhead sports as well

as high performance levels, shoulder joint hyperlaxity, glenoid and humeral head bone defects, and failed prior stabilization surgery.<sup>2,3</sup>

Among these factors, glenoid bone loss with or without humeral bone defects is commonly found after

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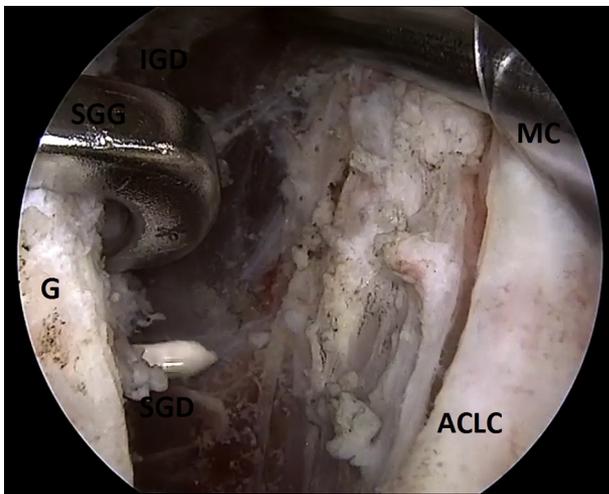
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**Fig 1.** Arthroscopic picture of the left shoulder, as viewed from anterosuperior portal; the patient was in the lateral decubitus position. A 15-mm metal cannula was introduced through the rotator interval, and a switching stick was passed through this cannula and used as a retractor moving the anterior capsulolabral complex anteriorly. The specific glenoid guide is passed through the posterior portal and centered at the anterior glenoid defect. The guide should be parallel and in contact with the glenoid surface. The superior 2.8-mm sleeved drill guide is advanced carefully, drilling the glenoid from the posterior to anterior region. Abbreviations: ACLC, anterior capsulolabral complex; G, glenoid; IGD, inferior glenoid defect; MC, metal cannula; SGD, superior glenoid drill; SGG, special glenoid guide.

the first shoulder dislocation in  $\leq 50\%$  of patients, increasing to 90% to 100% of patients with recurrent glenohumeral instability.<sup>4-6</sup> In addition, there is evidence that each instability event results in cumulative reduction in glenoid width and glenoid bone defect.<sup>4</sup>

Bone block procedures aim to fill in the glenoid bone defects and restore normal glenoid anatomy in patients with recurrent shoulder instability. The German surgeon Rudolf Theis Eden performed the first bone block procedure with the use of a tibial graft on March 25, 1917; Oscar Samuel Hybinette, a surgeon from Sweden, performed the same procedure 10 days later.<sup>7,8</sup> Because Hybinette first harvested the bone graft from the iliac crest, this area has remained the main autograft donor site, offering either bicortical or tricortical J-shaped grafts.<sup>9</sup> The primary points of evolution identified in the hundred-year-old Eden-Hybinette procedure are the changeover from open surgery to arthroscopy, use of allograft, manufacture of special glenoid guides to optimize graft positioning, and evolution of graft fixation methods from screws to buttons or no fixation devices.<sup>9-12</sup> The all-arthroscopic modified Eden-Hybinette procedure provides promising short-term results, not only as a primary surgery option, but also in revision operations.<sup>13-15</sup> However, very few studies have evaluated the safety and effectiveness of this recently modified technique in short-term follow-up;

further, no study to our knowledge has evaluated the mid- to long-term outcomes.

The purpose of this study is to evaluate the clinical, functional, and radiological midterm outcomes of the all-arthroscopic modified Eden-Hybinette procedure in patients with recurrent anterior shoulder instability. Our hypothesis was that this technique is safe and effective, leading to excellent clinical, functional, and radiological midterm outcomes.

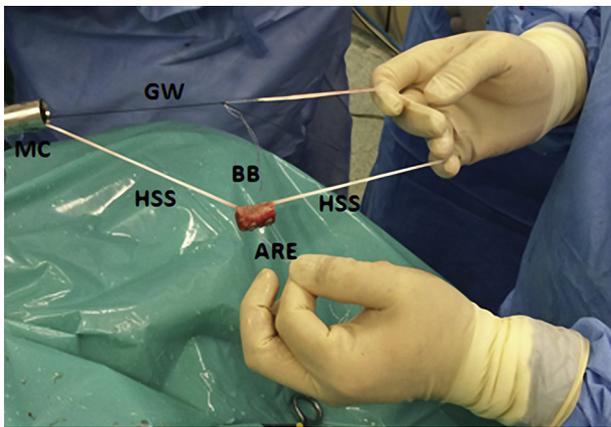
## Methods

The study's protocol was approved by the scientific committee of our hospital in line with the principles of the Helsinki Declaration. All patients participated voluntarily and did not receive any compensation. They were all preoperatively informed in both oral and written manner about treatment options. For confirmation, they all provided written consent.

A retrospective, single-center, level IV case series was conducted based on prospectively collected data. We reviewed patients who were treated arthroscopically by the same senior shoulder surgeon (E.A.) and surgical team from 2015 to 2017. This study dealt with patients with traumatic unidirectional anterior shoulder instability with  $\geq 1$  recurrence and  $\geq 8\%$  glenoid bone loss, who were treated primarily or had to undergo revision surgery owing to a previously failed arthroscopic Bankart repair procedure. The study excluded patients with glenoid bone loss  $< 8\%$  as well as those with atraumatic or multidirectional shoulder instability.



**Fig 2.** The specific glenoid guide has two 2.8-mm sleeved bullets. The guide was passed through the posterior portal, and its hook tip was passed along the glenoid and positioned to the center of the bone defect. When the position was optimal, a bullet was placed through each of the 2 guide holes and driven into contact with the posterior glenoid. A 2.8-mm sleeved drill guide was advanced carefully through each of the bullets, drilling the glenoid from posterior to anterior. Two parallel 2.8-mm tunnels were drilled 5 mm deeper from the articular surface of the glenoid (specific instruments created by Smith & Nephew). Abbreviations: HT, hook tip; SDG, sleeved glenoid drill.



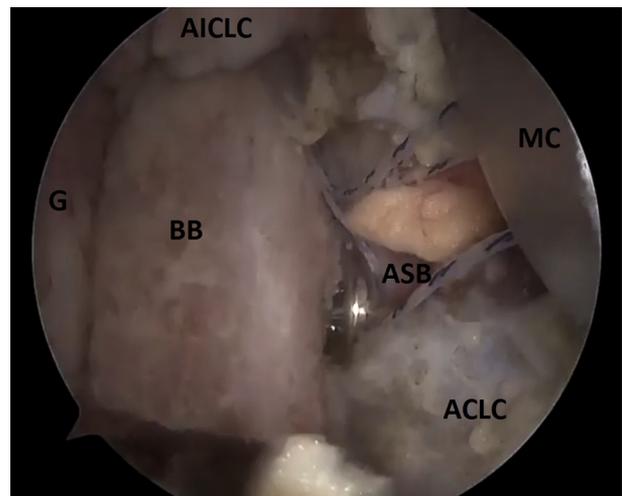
**Fig 3.** Intraoperative picture of the right shoulder. The metal cannula was positioned in the anteroinferior portal, and the patient was in the lateral decubitus position. Two guide wires were passed through the specific glenoid guide's metal sleeves from posterior to anterior and retrieved from the anteroinferior metal cannula. Each guide wire was loaded with a high-strength orthopedic suture that passed through the bone block and ended at an anterior round Endobutton fixation device. The sutures were retrieved from the posterior end, through the metal cannula, and through the glenoid tunnels, and bone block was inserted into the joint and set in position. Abbreviations: ARE, anterior round Endobutton; BB, bone block; GW, guide wire; HSS, high strength suture; MC, metal cannula.

### Surgical Technique

The patient was placed in the lateral decubitus position, and the affected shoulder was placed at 70° of abduction and 15° of forward flexion with 2 to 3 kg of traction. The arthroscope was introduced through the posterior portal, standard anterosuperior and anteroinferior portals were created, and 75-mm cannulas were positioned. A standard arthroscopy was performed under general anesthesia, and a diagnostic examination of the joint was performed. A bone block of 2 × 1 × 1 cm was obtained from the anterior iliac crest and prepared with a graft preparation tool (Smith & Nephew, London, UK). Keeping the arthroscope in the anterosuperior portal, a part of the rotator interval was removed, and the anterior labrum-capsule complex was mobilized completely from the anterior glenoid neck with the subscapularis tendon left intact. A specific posterior glenoid guide (Smith & Nephew) was passed through the posterior portal, and its hook tip was passed along the glenoid and positioned to the center of the bone defect (Figs 1 and 2). When the position was optimal, a bullet was placed through each of the 2 guide holes. Two small skin incisions were made, a blunt mosquito clamp was used to spread the soft tissue, and both bullets were driven into contact with the posterior glenoid. A 2.8-mm sleeved drill guide was advanced carefully through each of the bullets, drilling the glenoid from posterior to anterior. Two

parallel 2.8-mm tunnels were drilled 5 mm deeper from the articular surface of the glenoid. When the drill bits were withdrawn, the metal sleeves were left in place.

Three double-loaded soft anchors (Juggerknot 1.5 mm; Zimmer Biomet, Warsaw, IN) were inserted in the glenoid articular surface at 5, 3, and 1 o'clock positions, with special care to avoid the already drilled glenoid tunnels. A 15-mm metal cannula was introduced through the rotator interval. Two guide wires were passed through the guide's metal sleeves from posterior to anterior and retrieved from the anteroinferior metal cannula. Each guide wire was loaded with a high-strength orthopedic suture ended with an anterior round Endobutton fixation device (Smith & Nephew) that passed through the bone block (Fig 3). The sutures were retrieved through the tunnels from the posterior end, and the bone block was inserted into the joint and set in position (Fig 4). Two posterior round Endobutton fixation devices were attached to the sutures, secured to the posterior wall of the glenoid with a doubled-suture Nice knot, and tensioned with a specific tensioning device (Smith & Nephew).<sup>16</sup> Finally, the anterior capsulolabral complex was repaired using 3 double-loaded soft anchors inserted at 5, 3, and 1 o'clock positions, and remplissage of the posterior capsule and infraspinatus was performed according to the technique described by Brilakis et al.<sup>17</sup>



**Fig 4.** Arthroscopic picture of the left shoulder, as viewed from anterosuperior portal; the patient was in the lateral decubitus position. A 15-mm metal cannula is introduced through the rotator interval. The bone block is inserted into the joint through the metal cannula and centered at the anterior glenoid defect and flush with the glenoid articular surface. Two pairs of 2 round buttons are connected with no. 5 high-strength orthopedic sutures, stabilizing the bone graft to the anterior glenoid rim. Abbreviations: ACLC, anterior capsulolabral complex; AICLC, anteroinferior capsulolabral complex; ASB, anterior superior button; BB, bone block; G, glenoid; MC, metal cannula.

In this way, the tension of the anterior and posterior capsules was restored and bone block became extra-articular.

### Postoperative Protocol

The operated shoulder was protected for 6 weeks in a simple sling. Daily activities were allowed during the first week, provided the motion of the shoulder was pain free and restricted to the anterior part of the body. Physical therapy started during the fourth postoperative week, increasing the range of motion gradually. Overhead activities were allowed when graft healing was confirmed after computed tomography (CT) evaluation at 3 months and return to sports after 6 to 9 months postoperatively, depending on rehabilitation progress.

### Primary and Secondary Outcome Measures

Patients were evaluated before and after surgery at 3 and 6 weeks; 3, 6, 9, and 12 months; and every year thereafter by an experienced shoulder surgeon from our department, other than the operative surgeon. A typical physical examination of the shoulder was carried out. An assessment of function was made using the American Shoulder and Elbow Surgeons (ASES) score, Oxford Instability score (OIS), Rowe Instability score (RIS), and Walch-Duplay score (WDS).

Preoperative x-rays and magnetic resonance imaging (MRI) were conducted to identify soft tissue lesions in the shoulder, and 3-dimensional CT (3DCT) was also conducted. To estimate the glenoid and humeral bone defects, the Osirix DICOM-viewer was used by a specialized musculoskeletal system radiologist and shoulder surgeon from our department. A best-fit circle was created on the intact posteroinferior margins of the 3D reconstructed injured glenoid, and the glenoid defect

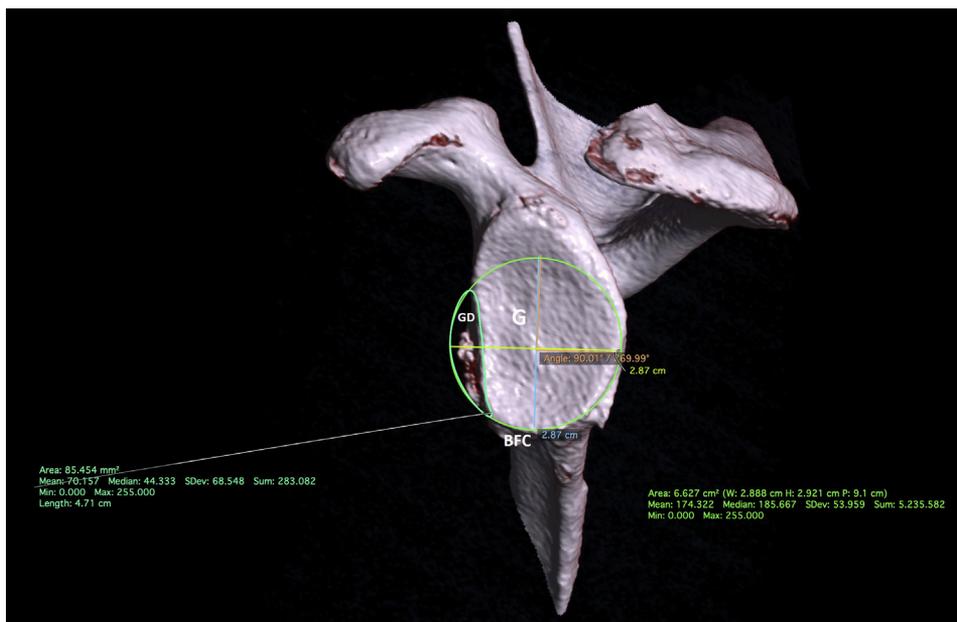
was calculated as the missing area of the circle (Fig 5).<sup>5,6,18,19</sup> Hill-Sachs lesions were also identified, using preoperative axial MRI and 3DCT images, and classified intra-operatively according to the Calandra arthroscopic classification as small (grade I), medium (grade II), or large (grade III).<sup>20</sup>

Patients underwent CT scans at 3 months and 1 year after surgery to evaluate graft positioning as well as healing and absorption. The graft position was considered medialized if it was  $\geq 5$  mm medial and lateralized if was  $>1$  mm lateral to the glenoid rim. We considered a graft subequatorial if  $\geq 50\%$  of the graft was positioned below the glenoid equator. The graft was considered healed to glenoid if bone continuity was visible on CT. Graft reabsorption was evaluated 1 year after surgery and considered partially or completely absorbed. Radiological examinations, including the patient standing in standard anteroposterior views, were routinely obtained every year. Additionally, each patient was evaluated for progression to arthrosis according to the Samilson and Prieto classification.<sup>21</sup>

The postoperative evaluation meticulously assessed stability of the operated shoulder. The presence of true recurrences, subluxations, positive apprehension tests, and subjective shoulder instability indicated failure of treatment. Finally, patients' overall satisfaction was recorded with a simple questionnaire.

### Statistical Analysis

Data analysis was performed with STATA version 13 (STATA Corp., College Station, TX). Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess the normality of data distribution. Comparisons of score values before and after intervention were performed with the paired *t* test for normally distributed differences



**Fig 5.** 3D computed tomography image of the left shoulder with the humeral head digitally subtracted using Osirix DICOM-viewer. To avoid inaccurate estimation of the glenoid width, the transverse, sagittal, and coronal planes are set before the evaluation of the defect. The best-fit circle is created on intact posteroinferior margins of the injured 3D reconstructed glenoid, and the glenoid defect is calculated as the missing area of the circle: Percentage area loss =  $GD/G \times 100\%$ , where *G* is glenoid and *GD* is glenoid defect. Abbreviation: BFC, best-fit circle.

**Table 1.** Demographic data (N = 28)

Characteristic	Value
Follow-up (mo)	43 ± 6
Age (y)	36 ± 10
Age at first dislocation (y)	21 (range 14 to 43)
Total dislocations	9.5 (range 2 to 100)
Glenoid bone loss (%)	12.4 (range 8 to 33)
Sex	
Male	24 (85.71%)
Female	4 (14.29%)
Injured side	
Right	25 (89%)
Left	3 (11%)
Dominant Hand	
Right	26 (92.86%)
Left	2 (7.14%)
Shoulder hyperlaxity	
Yes	10 (35.7%)
No	18 (64.3%)
Type of work	
Office	22 (78.6%)
Strenuous	6 (21.4%)
Sports participation	
Yes	26 (92.9%)
No	2 (7.1%)
Level of sports	
Competitive	11 (39.3%)
Recreational	15 (53.5%)
None	2 (7.2%)
Type of sport	
Contact/force	
Overhead	20 (74.07%)
Other	5 (18.52%)
None	2 (7.41%)
Hill-Sachs lesions	
Small	0 (0%)
Medium	15 (53.6%)
Large	13 (46.4%)

Data are mean ± standard deviation (normally distributed continuous data), median (range) (non-normally distributed continuous data), or n (%) (discrete data).

and nonparametric Wilcoxon's signed-rank test otherwise. All reported *P* values were based on 2-sided tests and compared at a significance level of 5%.

## Results

The final study cohort included 28 patients, and all (100%) were available for evaluation after surgery for the minimum 3-year follow-up. The mean follow-up period was 43 ± 6 months, with minimum 3-year follow-up (range 36 to 53). The mean patient age at the time of evaluation was 36 ± 10 years (range 21 to 54). Among the 28 patients included in the study, 24 were male (85.71%) and 4 were female (14.29%). The demographics of the patients are illustrated in [Table 1](#).

No recurrences were presented as new dislocations, subluxations, positive apprehension tests, or subjective complaints of shoulder instability among this group of patients, postoperatively. At the last follow-up, all patients reported that they had a stable shoulder. The

overall recurrence rate was therefore 0%, and no revision surgeries were documented.

All patients returned to work, and 73% of the patients (19 of 26) returned to their previous sports activities at the desired level; 11.5% (3 of 26) returned at 80% to 90% of the desired level; and 15.5% (4 of 26) did not return to their sports.

There was no statistically significant change to the postoperative values of the range of motion of the shoulder compared with the patients' respective preoperative group values. In addition, the postoperative values of the range of motion of the shoulder had no significant difference compared with contralateral healthy shoulders. The shoulder range of motion values are documented in [Table 2](#).

All final postoperative functional scores improved to excellent levels in comparison with preoperative values. In particular, there was a statistically significant increase in the ASES, OIS, RIS and WDS, *P* < .001 ([Table 3](#)). Twenty-five patients (89.3%) reported excellent overall satisfaction, and 3 patients (10.7%) reported moderate satisfaction. No patient was dissatisfied.

## Graft Positioning, Healing, and Reabsorption

All patients were evaluated with CT preoperatively, and 23 of the 28 (82.1%) were evaluated at 3 months and 1 year postoperatively. Five patients refused to undergo CT or MRI scans postoperatively, but they attended the rest of the follow-up examinations. The CT evaluations at 3 months postoperatively showed that optimal graft positioning and healing was achieved in all cases. The graft was flush to glenoid surface in all but 1 case and subequatorial in all cases. In 1 case, the autograft was positioned ~5 mm medially to the glenoid.

In the CT scan results 1 year after the procedure, all grafts had healed to the glenoid, and complete bone graft reabsorption was not documented in any patient; partial graft reabsorption occurred in 2 cases. In these 2 cases, the remaining graft was about one-third smaller than in the CT scan results 3 months after surgery.

## Complications

No neurological or other major complications were documented, and no patient required further surgery. Two cases with transient lateral femoral cutaneous nerve palsy from iliac crest harvesting resolved spontaneously during the second month after surgery. In 2 cases, the graft fractured intraoperatively during the compression of 1 pair of buttons; in both cases, the graft stabilized successfully just with the other pair of buttons. Evaluation of the glenohumeral arthrosis, conducted according to Samilson and Prieto,<sup>21</sup> revealed 1 patient with mild arthrosis (osteophyte <3 mm on the humeral head), 3 years after surgery. The patient was

**Table 2.** Statistical analysis of shoulder (and contralateral shoulder) range of motion measurements before surgery and at the latest follow-up

Measurement	Forward Flexion (°)	External Rotation at 0° Abduction (°)	External Rotation at 90° Abduction (°)	Internal Rotation (°)
Preoperative	175 ± 19.2	75.2 ± 19	87.5 ± 17.1	T10 (T4-L5)
Postoperative	180 ± 0	80.9 ± 14.3	86.25 ± 10	T7 (T4-L3)
P value	.17	.21	.74	.15
Postoperative	179.6 ± 1.9	80.9 ± 14.3	86.25 ± 10	T7 (T4-L3)
Contralateral	180 ± 0	85 ± 1.9	89.6 ± 1.9	T7 (T4-L3)
P value	.27	.14	.09*	.999

Data are mean ± standard deviation.

L, lumbar vertebra; T, thoracic vertebra.

\*Statistically significant.

free of pain at his last follow-up but faced restrictions in the affected shoulder's range of motion. No cases of postoperative infection occurred.

## Discussion

The most important finding of this study is that the all-arthroscopic modified Eden-Hybinette procedure is safe and effective, leading to excellent clinical, functional, and radiological midterm outcomes. The overall recurrence rate among these 28 patients was 0%. Further, no subjective instability symptoms were reported, and no revision surgeries were documented. The addition in the existing literature is that the results continue to be valid after 3 years. This is very important for instability cases, because independently of the technique selected, recurrence rates increase as time passes. Thus, the success rate of every procedure used for instability management is evaluated in the long term.

The reported recurrence rates in literature were similar to our results and ranged from 1% to 6% for the Eden-Hybinette procedure as well as for the well-documented Latarjet procedure.<sup>14,22-25</sup> In the most recent literature, a systematic review by Malahias et al.<sup>22</sup> followed 231 patients from 9 studies with a mean follow-up ranging from 20.6 to 42 months for patients who had undergone open or arthroscopic iliac crest surgery. The rate of recurrent instability was 4.8%, and the overall all-cause reoperation rate was 6.1%.<sup>22</sup> Taverna et al.<sup>14</sup> presented arthroscopic bone block procedure results similar to our study, in 26 patients with an average follow-up of 29.6 months and no recurrent anterior dislocations; however, 1 patient experienced traumatic posterior dislocation.

**Table 3.** Statistical analysis of preoperative and postoperative functional scores

Timing	ASES	OIS	RIS	WDS
Preoperative	79.1 ± 16.3	24.7 ± 8.3	43.2 ± 18	52.5 ± 20
Postoperative	93.3 ± 1.3	44.2 ± 1.6	90.2 ± 2.8	95.5 ± 1.9
P value	<.001	<.001	<.001	<.001

Data are mean ± standard deviation.

ASES, American Shoulder and Elbow Surgeons score; OIS, Oxford Instability score; RIS, Rowe Instability score; WDS, Walch-Duplay score.

Giannakos et al.<sup>13</sup> published a cohort of 12 patients with recurrent instability cases, of which 10 had a Latarjet procedure as an index surgery and 2 had a Bankart repair procedure. All the procedures were revised with the arthroscopic Eden-Hybinette technique using an autologous bicortical iliac crest bone graft. The average follow-up period was 28.8 months. A positive apprehension test persisted in 5 patients (42%), including 2 patients (17%) with recurrent subluxations.<sup>13</sup> Some authors have suggested that the all-arthroscopic Eden-Hybinette procedure is a safe, effective, and reproducible technique for revision surgery for patients with failed shoulder instabilities.<sup>13,23,24</sup> Metais et al.<sup>23</sup> reported that the recurrence instability of the Latarjet procedure with a mean follow-up period of 28 months can be as low as 1% to 3% with appropriate indications and technique. Another recent systematic review by Cerciello et al.<sup>25</sup> analyzed 14 studies with 813 patients who underwent open and arthroscopic Latarjet procedures with a mean follow-up period of 24.5 months, reporting that the overall complication rate was 16.5%, recurrence rate 2.6%, and revision surgery 6.3%. According to the same study, the arthroscopic subgroup cohort recurrence rate was 6.5% and revision surgery rate was 5.7%.<sup>25</sup>

The all-arthroscopic Eden-Hybinette procedure seems to be an extremely safe technique, presenting only the general risks of an arthroscopic procedure without major neurovascular complications reported in recent literature.<sup>13,14,22,26</sup> In our study, major complications were avoided after the same standardized operation carried out by the same senior surgeon and surgical team experienced in arthroscopy. We avoided the major neurovascular structures of the anterior part of the shoulder by using standard arthroscopic portals, inserting a specific glenoid guide, and performing tunnel drilling from the posterior to anterior regions in a safe and reproducible manner. The incidence of neurovascular complications reported in the Latarjet procedure range from 1% to 20%, and the axillary and musculocutaneous nerves are typically in danger, in addition to chances of injury to the suprascapular nerve.<sup>24</sup> Gartsman et al.<sup>27</sup> demonstrated that the overall complication rate was 5%, and 13 neurologic

injuries occurred (3.1%), of which 7 occurred to the axillary nerve, 4 to the musculocutaneous nerve, and 2 to the suprascapular nerve, and 2 patients reported multiple nerves affected, in a retrospective chart review of 416 Latarjet procedures.<sup>27</sup> According to Metais et al.,<sup>23</sup> major complications occurred in 19 of 390 patients (4.8%) who underwent the Latarjet procedure, and nerve injuries occurred in 3 cases, of which the supra-scapular nerve was impacted in 2 and musculocutaneous nerve in 1.

Using only 2 pairs of small round buttons to stabilize the bone graft and avoiding potentially harmful hardware such as metal screws also enhances the safety of this technique. For that reason, hardware-related damage to articular surfaces can be avoided, and there is no need for copious hardware removal in case of recurrence or future surgical interventions in the same shoulder. Techniques and equipment required in using buttons have been described for years, but more time is needed for their use to become widespread.<sup>12,28-30</sup> Major complications related to hardware were absent in our study, and the only hardware-related problems were 2 cases in which the graft fractured during the final compression. However, both patients had excellent postoperative functional scores, and their graft positioning and healing were optimal.

In contrast, using metal screws close to the glenohumeral joint can result in complications and require arthroscopic screw removal. Hardware-related complications such as screw breakage or symptomatic mechanical irritation around the screw insertion occurred in 3.9% of the patients in a systematic review for the Eden-Hybinette procedure.<sup>22</sup> Similarly, Griesser et al.<sup>31</sup> reported a 7% reoperation rate out of 1,904 Latarjet procedures, with nearly 35% of these being symptomatic hardware removal cases due to hardware failure.

Patients' overall satisfaction for the Eden-Hybinette procedure in our study was excellent and at a very high rate, and only 10.7% patients stated moderate (versus excellent) satisfaction owing to small restrictions in their shoulders' range of motion. All the patients' complaints or sensitivities concerning the area of graft harvesting were eliminated 3 to 6 weeks postoperatively. All the patients declared that they would repeat this kind of treatment. The comparison of the operated shoulders with contralateral healthy shoulders in our study revealed a non-statistically significant reduction in the shoulders' external rotation. Several studies in literature have reported high satisfaction rates and did not find significant differences in any of the different elements of postoperative range of motion compared with the healthy contralateral side.<sup>14,15,22,26,32,33</sup> However, the results for the Latarjet procedure differ; some report that the loss of external rotation is  $\sim 5^\circ$  with open or arthroscopic techniques,

and others report stiffness and significant loss of external rotation.<sup>23,24,34</sup>

Most of the patients included in our study returned to their sports at the desired level. Those who returned at lower levels or did not return at all reported that this was a consequence of a change in their lifestyle due to the chronicity of their problem and not because of subjective feelings of instability or fear. Both Taverna et al.<sup>14</sup> and Giannakos et al.<sup>13</sup> found results similar to ours after using the arthroscopic Eden-Hybinette technique, and Anderl et al.<sup>33</sup> noted that all patients after glenoid reconstruction with an arthroscopic implant-free J-bone graft returned to their preinjury level of athletic activity within 6 months after surgery.

In the current study, continuous evaluation revealed that 1 patient progressed to mild glenohumeral arthrosis according to the Samilson and Prieto classification.<sup>21</sup> Before the operation, the patient had dislocated his shoulder  $\sim 50$  times, and the surgery was 15 years after his first dislocation, but he had no signs of arthrosis preoperatively or during the arthroscopic procedure. A connection to the advancement of glenohumeral arthrosis and bony reconstruction procedures in patients with recurrent shoulder dislocations and procedures is often reported in the literature. In their study including 43 instability cases treated with iliac crest graft augmentation, Steffen and Hertel<sup>35</sup> reported 20% progression to grade I arthrosis, according to the Samilson and Prieto classification,<sup>21</sup> after a follow-up period ranging from 5 to 19 years. However, in a meta-analysis of arthroscopic and open instability procedures, Longo et al.<sup>36</sup> compared the incidence of postoperative osteoarthritis after bone block procedures and Bankart repairs and found that there was no significant difference between the 2 groups. Postoperative osteoarthritis rates in the Latarjet procedure are similar to any type of intra-articular surgery, with no difference between open Latarjet and open anterior capsulolabral fixations, according to a recent review by Domos et al.<sup>24</sup>

A phenomenon related to bone block procedures is osteolysis or the failure of graft incorporation. A theory based on Wolff's law supports that if a part of the graft is not loaded, it is resorbed.<sup>15</sup> In our study cohort, partial graft reabsorption occurred in 2 cases. However, the tissue existing in place of the partial reabsorption had a density of 70 Hounsfield units, corresponding to dense connective tissue values, and further, both patients had excellent outcomes. Similar findings were demonstrated by Taverna et al.<sup>14</sup> where the bone block was healed in 92.3% at a mean 29.6-month follow-up period.<sup>14</sup> Osteolysis or the failure of graft incorporation is a well-known occurrence that is also prevalent in the Latarjet procedure. A systematic review by Griesser et al.<sup>31</sup> analyzing 45 studies including 1,904 shoulders demonstrated a nonunion rate of 9.4% of total cases. In a study based on CT scan analysis, 26 patients were

prospectively monitored for 14 months, wherein Di Giacomo et al.<sup>34</sup> showed that 59.5% had significant osteolysis mostly in the superficial part of the proximal coracoid, with no clinical significance in terms of recurrent instability.<sup>34</sup>

The glenoid bone loss threshold that can be accepted to perform arthroscopic soft tissue stabilization techniques is still not clearly defined.<sup>1,6,37</sup> Recent studies have suggested that glenoid bone loss from 10% to 13.5% may be an appropriate threshold, considering that Bankart repair procedures may fail, especially in patients with several risk factors.<sup>38-41</sup> The reproducibility and safety of the all-arthroscopic Eden-Hybinette procedure was a sufficient argument to consider a glenoid bone loss of 8% as the threshold to perform a glenoid reconstruction procedure in patients with recurrent shoulder instability. The glenoid defect alone should not be used to make a selection between a soft tissue and bony procedure: other patient risk factors should be taken into consideration to individualize treatment and reduce the risk of recurrence.<sup>2,38,39</sup>

When the decision to perform a bony procedure after shoulder dislocation is taken, the aim is to restore the normal glenoid anatomy and, therefore, shoulder stability. The undisturbed normal shoulder anatomy after an all-arthroscopic Eden-Hybinette procedure is indisputably the most superior advantage of this procedure compared with Latarjet, assuming that both are equally safe and effective to restore glenohumeral stability. There is no need to transfer the coracoid process, which is one the most important anatomic landmarks in shoulder surgery, and the subscapularis tendon remains untouched, which gives assurance that if a revision surgery or future shoulder procedure is required for any reason, it will be as easy as the primary case.

The strengths of this study include the fact that all the patients were available for follow-up and the data collection was prospective. Also, all procedures and patient evaluations were performed by the same senior shoulder surgeon, who was assisted by the same team.

### Limitations

There are several limitations to this study. The retrospective design and absence of a control group could introduce bias. The preoperative and postoperative evaluation of the patients was performed by experienced shoulder surgeons from our department, but not by independent observers, and it is possible that the selection, detection, and assessment biases may have affected the aforementioned results.

### Conclusions

The all-arthroscopic modified Eden-Hybinette procedure is safe and leads to excellent clinical and radiological midterm outcomes in patients with recurrent

anterior shoulder instabilities. This procedure restores the glenoid bone defects while preserving normal shoulder anatomy.

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