

All-inside ramp lesion repair via anterior portals and pie-crusting: Excellent outcomes and survivorship at one-year follow-up

Antonio Clemente^{a,b}, Domenico Zaccari^c, Federico Verdone^d, Glauco Loddo^e,
 Francesco Bosco^{f,g,*}, Francesco Saccia^{a,b}

^a Humanitas Cellini, Via Cellini 3, 10126, Torino, Piemonte, Italy

^b Co.Gi.To – Conservativa Ginocchio Torino, Via Cassini 71, Torino, Piemonte, Italy

^c University of Bari, Piazza Umberto I, 1, 70121, Bari, Puglia, Italy

^d University of Turin, Department of Surgical Sciences, Corso Dogliotti 14, 10126, Torino, Piemonte, Italy

^e Santo Spirito Hospital, Viale G. Giolitti 33, 15033, Casale Monferrato (AL), Piemonte, Italy

^f Department of Precision Medicine in Medical, Surgical and Critical Care (Me.Pre.C.C.), University of Palermo, 90133, Palermo, Italy

^g Department of Orthopaedics and Traumatology, G.F. Ingrassia Hospital Unit, ASP 6, 90131, Palermo, Italy

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ABSTRACT

Background: Ramp lesions, located in the posterior horn of the medial meniscus, are commonly associated with anterior cruciate ligament (ACL) injuries and contribute to knee instability if untreated. Traditional repair methods use posteromedial portals, but newer approaches, such as the all-inside technique through anterior arthroscopic portals with pie-crusting of the posterior oblique ligament (POL), offer improved access and reduced morbidity. This study aimed to assess the clinical outcomes, return-to-sport rates, and failure rates of this technique compared to established methods.

Materials and methods: A retrospective analysis included 54 patients (mean age: 29.1 years) who underwent ramp lesion repair using the all-inside technique between January 2019 and December 2022. Clinical outcomes were evaluated with the IKDC score, Lysholm score, and Tegner activity scale. Failure was defined as the need for revision surgery.

Results: At a mean follow-up of 30.7 months, patients had a mean IKDC score of 81.5 ± 7.1 and Lysholm score of 94.5 ± 7.4 . The Tegner activity scale declined slightly from 7.2 ± 1.2 preoperatively to 6.8 ± 1.3 post-operatively. All patients returned to sport within 9.2 ± 2.5 months, with a failure rate of 12.9 % and an average revision time of 13.1 ± 8.2 months.

Conclusion: The all-inside technique for ramp lesion repair via anterior portals provides excellent clinical outcomes and return-to-sport rates, with failure rates comparable to other methods. This minimally invasive approach offers improved access, reduced morbidity, and a reliable option for managing ramp lesions in ACL-injured patients.

Level of evidence: IV.

1. Introduction

Ramp lesions, first described by Strobel, are meniscosynovial or meniscocapsular tears located at the posterior horn of the medial meniscus. These lesions are commonly associated with anterior cruciate ligament (ACL) injuries and have been reported to occur in approximately 9.3 %–17 % of such cases.^{1–3} Despite their relatively high incidence, ramp lesions often go undiagnosed due to the inherent limitations

in visualizing the posteromedial corner of the knee using standard anterior arthroscopic portals.⁴ This diagnostic challenge represents a critical issue, as failure to identify and adequately repair ramp lesions can contribute to anteroposterior knee instability, secondary medial meniscal damage, and early failure of ACL reconstruction.^{5,6}

Over the years, numerous surgical techniques have been proposed to repair ramp lesions. One of the most widely utilized approaches involves the use of a posteromedial portal and a suture hook for lesion

* Corresponding author. Department of Precision Medicine in Medical, Surgical and Critical Care (Me.Pre.C.C.), University of Palermo, 90133, Department of Orthopaedics and Traumatology, G.F. Ingrassia Hospital Unit, ASP 6, 90131, Palermo, Italy. francescobosco@icloud.com

E-mail address: francesco.bosco03@unipa.it (F. Bosco).

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visualization and repair. The trans-septal portal technique has also been introduced, allowing enhanced access to the posterior compartment while employing a hook device through the posteromedial portal.^{8–10} More recently, Choi et al. proposed a technique that utilizes anterior arthroscopic portals in conjunction with the pie-crusting of the medial collateral ligament (MCL) to improve access to the posteromedial compartment.^{11,12} Despite these advancements, there remains no clear consensus regarding the superiority of one technique over another, nor is there a universally recognized gold standard for ramp lesion repair. Some authors have expressed concerns about the effectiveness of anterior portal-based techniques, citing a higher risk of repair failure.⁷

The lack of consensus in the literature highlights a significant gap in the current understanding of the optimal surgical approach for ramp lesions. Additionally, limited evidence compares the clinical outcomes and complication rates associated with different repair techniques. Developing effective, minimally invasive strategies that ensure optimal repair outcomes while reducing morbidity remains a key area of focus in orthopedic research.

The aim was to evaluate the clinical outcomes, return to sports activities, and suture failure rates associated with ramp lesion repair using an all-inside repair technique through anterior arthroscopic portals. The hypothesis was that this technique would yield clinical results comparable to or superior to other established meniscal repair methods while offering reduced morbidity and reliable functional outcomes.

2. Materials and methods

2.1. Study design and ethical approval

This study was designed as a multi-center retrospective case series, utilizing data from a prospectively collected database. A single surgeon performed all surgical procedures between January 2019 and December 2022. Ethical approval was obtained from the institutional review board, and all patients provided informed consent before inclusion. The study was conducted by the principles outlined in the Declaration of Helsinki.

2.2. Inclusion and exclusion criteria

Patients included in the study had confirmed ramp lesions. They met at least one of the following criteria: complete anterior cruciate ligament (ACL) injury, partial ACL lesions with residual instability, lateral meniscus tears, or ACL revision reconstruction. Exclusion criteria included suspected ramp lesions not confirmed arthroscopically, patients with less than one year of follow-up from surgery, those with prior open or arthroscopic surgeries for intra-articular lesions, and ramp lesions treated using alternative surgical techniques. Ramp lesions were classified according to the Thunat classification system.⁴

2.3. Data extraction

Demographic, clinical, and surgical data were extracted from the database, including lesion characteristics, details of surgical techniques, and postoperative outcomes. Data on the time to return to sport and postoperative complications were stratified to analyze differences in recovery trajectories. Postoperative evaluations were conducted during outpatient visits and included clinical assessments alongside patient-reported questionnaires. Clinical outcomes were assessed using the Lysholm Knee Score¹³ and the International Knee Documentation Committee (IKDC) Objective Score.¹⁴ Return to sports (RTS) activity was evaluated using the Tegner Activity Scale,¹⁵ comparing the pre-injury and postoperative activity levels. Time to return to sport was analyzed, specifically focusing on patients without postoperative complications. Failures were defined as persistent clinical medial knee pain with positive meniscal tests that required subsequent partial meniscectomy. All postoperative complications were recorded.

2.4. Surgical technique

All procedures were carried out with the patient in the supine position and the knee flexed to 90°. A tourniquet was applied to the operative limb, and arthroscopy was performed to confirm the presence of ramp lesions. The pie-crusting of the posterior oblique ligament (POL) was performed to improve visualization of the posterior horn of the medial meniscus and reduce iatrogenic cartilage damage (Figs. 1 and 2).

The stability of the posterior horn of the medial meniscus was evaluated using an arthroscopic probe from both anterior and trans-notch views. Surgical repair was recommended for unstable posterior horn lesions, inadequate contact between the posterior horn and the posterior capsule, or tears longer than 1 cm. Repairs were performed using the all-inside suture technique with the FAST-FIX™ 360 Meniscal Repair System (Smith + Nephew), adjusting the number of sutures based on the tear size. Optimal stability and contact between the posterior horn and the capsule were confirmed during the operation.

In concurrent ACL reconstruction cases, graft selection was tailored to individual patient characteristics such as age, sex, and activity level. Grafts included hamstrings, quadriceps tendon, and bone-patellar tendon bone. The modified "over-the-top" technique described by Marcacci was also utilized.¹⁶ At the end of the procedure, an intra-articular injection of 7 % ropivacaine (10 mL) and tranexamic acid (15 mL) was administered. No postoperative drainage was used.

2.5. Postoperative rehabilitation protocol

Postoperative rehabilitation followed a standardized protocol. Patients were instructed to begin non-weight-bearing motion immediately after surgery, with knee flexion restricted to 90° for the first four weeks. During this period, partial weight-bearing with crutches and a range of motion between 0° and 90° were allowed. For patients with additional meniscal lesions, such as radial or root tears, weight-bearing was prohibited for 40 days, with knee flexion restricted to 90° for the first four weeks.

After four weeks, a full non-weight-bearing motion was permitted, while weight-bearing knee flexion remained limited to 90° for five months. Full weight-bearing flexion was allowed after this period. Jogging was permitted at six months, and in cases involving ACL reconstruction, return to sport was allowed between eight and ten months. No braces were used during the rehabilitation process.

2.6. Statistical analysis

Descriptive statistics were calculated for demographic, clinical, and surgical data. Continuous variables were expressed as means $\pm$ standard deviations (SD), while categorical variables were presented as frequencies and percentages. A Kaplan-Meier survival analysis was conducted to evaluate the survivorship of ramp lesion repair, with failure defined as the need for revision surgery. The survival curve provided insights into the timing and frequency of failures over the follow-up period. Statistical analyses were performed using R software (version 4.1.3, R Core Team, Vienna, Austria).

3. Results

3.1. Patient demographics and clinical characteristics

A total of 65 patients were initially enrolled in the study. Of these, two patients (3.2 %) were excluded due to undergoing posteromedial hook repair, 5 (7.8 %) were unavailable for clinical evaluation, and 4 (6.4 %) were lost to follow-up. Consequently, 54 patients met the inclusion criteria and were included in the final analysis (Fig. 3). The cohort consisted of 40 males (74.0 %) and 14 females (26.0 %), with a mean age of 29.1 years (SD $\pm$ 10.4, range 13–56). The operated knee was the right knee in 30 cases (55.6 %) and the left knee in 24 cases

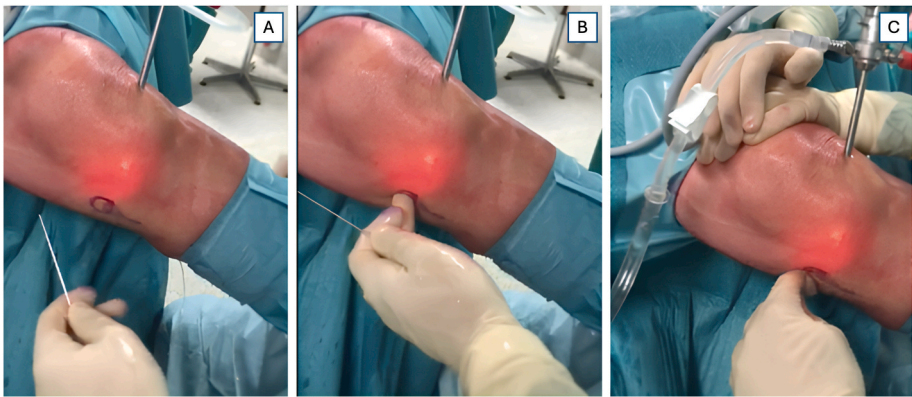


Fig. 1. The pie-crusting technique of the posterior oblique ligament. (A) Marking the adductor tubercle as a key anatomical landmark. (B) Insertion of a spinal needle to perform the pie-crusting procedure, enabling gradual ligament release. (C) Completing the pie-crusting technique facilitates improved arthroscopic access to the posterior horn of the medial meniscus.

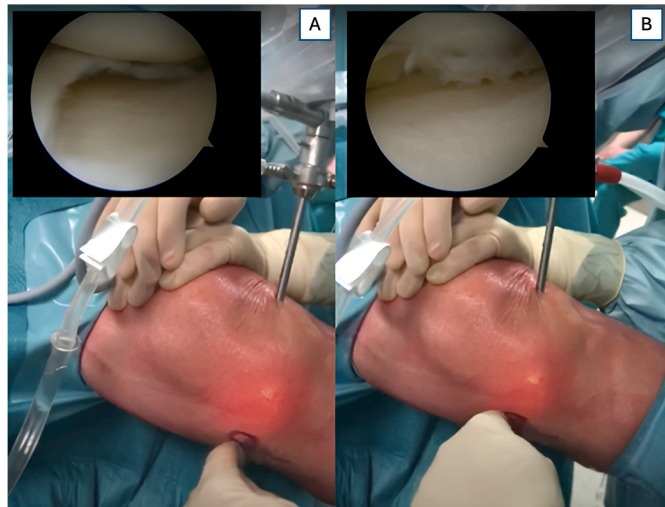


Fig. 2. Arthroscopic visualization of the posterior horn of the medial meniscus. (A) Limited visualization of the posterior horn before pie-crusting of the posterior oblique ligament. (B) Enhanced visualization after the pie-crusting procedure, providing optimal access for thorough evaluation and repair.

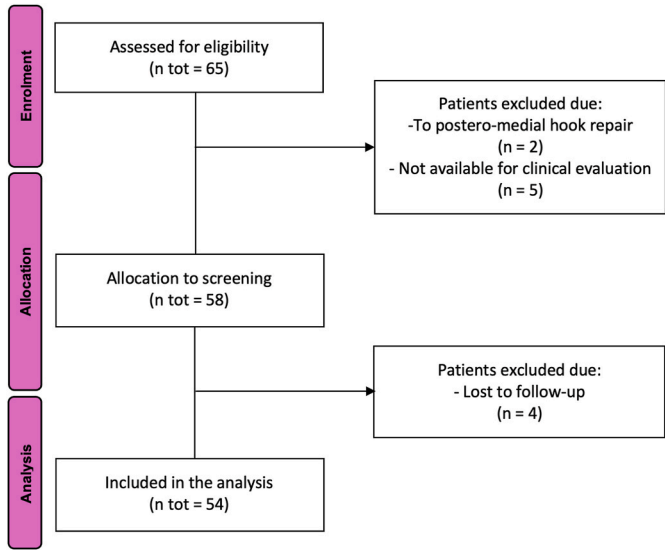


Fig. 3. Flowchart of patient selection and analysis.

(44.4 %). The mean follow-up duration was 30.7 months (range 12–58). Detailed demographic data and clinical characteristics are summarized in [Table 1](#).

3.2. Ramp lesion characteristics and associated pathologies

Ramp lesions were associated with ACL injuries in 87.0 % of cases (n = 47), of which 10 patients (21.3 %) experienced a re-rupture of the ACL. In 7 patients (12.9 %), Ramp lesions occurred due to rotational instability of the knee following ACL reconstruction. In 21 cases, it was possible to classify the ramp lesions: 2 cases (9.5 %) were Type II, 6 cases (28.6 %) were Type III, 4 cases (19.0 %) were Type IV, and 9 cases (42.9 %) were Type V. Rotational instability of the knee, as assessed by a positive pivot shift test, was identified in 35 patients (64.8 %) post-injury.

3.3. Surgical techniques

All patients underwent ramp lesion repair using the all-inside suture technique with the FAST-FIX™ 360 Meniscal Repair System (Smith + Nephew), with an average of 2.2 ± 0.9 sutures per procedure. ACL reconstruction was performed in 47 patients, with the most common technique being the all-inside anatomical reconstruction (n = 43). Hamstring grafts were utilized in 31 cases, quadriceps tendon in 11 cases, and bone-patellar tendon-bone (BPTB) grafts in 5 cases. Lateral tenodesis was performed in 29 patients (54.7 %) using the modified Arnold-Cocker technique. Detailed information on surgical techniques and procedures is available in [Table 2](#).

3.4. Clinical outcomes and return to sport

Postoperative outcomes demonstrated significant improvements in clinical scores. The mean IKDC score was 81.5 ± 7.1 , and the Lysholm

Table 1
Patient demographics and clinical characteristics.

Characteristics	Values
Included patients, N (%)	54
Age (years) Mean $\pm$ SD	29.1 $\pm$ 10.4
Age range (years)	13–56
Sex (Male), N (%)	40 (74.0)
Sex (Female), N (%)	14 (26.0)
Operated knee (Right), N (%)	30 (55.6)
Operated knee (Left), N (%)	24 (44.4)
Mean follow-up (months)	30.7
Follow-up range min-max (months)	12–58

N: number of evaluation cases; %: percentage; SD: Standard Deviation.

Table 2
Distribution of procedures, grafts, and associated meniscal lesions in ACL reconstruction cases.

Procedure/Technique	Cases (n)	Percentage (%)
ACL Reconstruction (All-inside)	43	79.6
Marcacci Over-the-Top ACL Reconstruction	4	7.4
Hamstring Graft	31	57.4
Quadriceps Tendon Graft	11	20.4
Bone-Patellar Tendon-Bone Graft	5	9.3
Ramp lesion sutures per procedure (Mean ± SD)	2.2 ± 0.9	–
Lateral tenodesis	29	54.7
Lateral tenodesis (Arnold Cocker)	22	75.9
Lateral tenodesis (Marcacci)	4	13.8
Lateral tenodesis (Lemaire)	3	10.3
Concomitant lateral meniscus tears	17	32.1
Root lesion of lateral meniscus (unstable)	4	–
Root lesion of lateral meniscus (stable)	3	–

ACL: Anterior Cruciate Ligament; SD: Standard Deviation; %: percentage; n: Number of evaluation cases.

score was 94.5 ± 7.4 at the final follow-up. All patients (100 %) returned to sports activities. The Tegner Activity Scale showed a mean pre-injury score of 7.2 ± 1.2 and a mean postoperative score of 6.8 ± 1.3 at 30.3 months follow-up. The average time to return to sport was 9.2 ± 2.5 months (Table 3).

3.5. Survivorship analysis and complications

The Kaplan-Meier survival curve indicated a failure rate of 12.9 % for ramp lesion repair at a mean follow-up of 30.7 months. Failures occurred, on average, after 13.1 ± 8.2 months (range 3–25). Causes of failure included re-tear of the ramp lesion during rehabilitation (n = 1), non-healing of the medial meniscus with persistent symptoms (n = 2), and reinjury during sports activities after return to play (n = 4). Details of failure cases are visualized in the survival curve (Fig. 4).

Overall, complications were rare. One patient (1.8 %) experienced a combined reinjury of the medial meniscus and ACL at 42 months post-operatively, which was attributed to a new meniscal tear in a different area. Three patients (5.6 %) had ACL reconstruction failure. Two patients (3.8 %) required additional surgeries for exostosis removal, and two patients (3.8 %) developed medial collateral ligament (MCL) laxity. Other complications included lateral meniscus tears (white-white zone) in two cases (3.6 %) and medial flexor tendinopathy in one case (1.8 %). A detailed summary of complications is provided in Table 4.

4. Discussion

The main finding of the present study is that repairing Ramp lesions through anterior arthroscopic portals with the all-inside suture technique, combined with pie-crusting of the posterior oblique ligament (POL), is a reliable and practical approach. This technique achieved high survivorship rates of 87.1 % at an average follow-up of 30.7 months, with a total failure rate of 12.9 %. The clinical outcomes were favorable, as demonstrated by mean IKDC and Lysholm scores of 81.5 and 94.5, respectively, and a return-to-sport rate of 100 %. These findings align with previous literature suggesting that Ramp lesion repair leads to

Table 3
Clinical outcomes and functional recovery.

Patient-Reported Outcome Measures (PROMS)	Value, Mean ± SD
Postoperative IKDC Score (Mean ± SD)	81.5 ± 7.1
Postoperative Lysholm Score (Mean ± SD)	94.5 ± 7.4
Pre-surgery Tegner Score (Mean ± SD)	7.2 ± 1.2
Post-surgery Tegner Score (Mean ± SD)	6.8 ± 1.3
Mean time to return to sport (months)	9.2 ± 2.5

PROMS: Patient-Reported Outcome Measures; IKDC: International Knee Documentation Committee; SD: Standard Deviation.

Kaplan Meier- Overall Survivorship Meniscal Repair

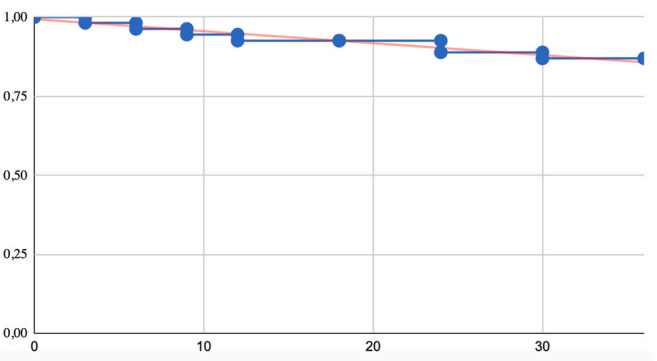


Fig. 4. Kaplan-Meier survival curve illustrating the survivorship of Ramp lesion repair.

Table 4
Failure rates and complications associated.

Failure rate and Complications	Cases
Ramp lesion repair failure rate, %	12.9 %
Failure rate (Time to failure, months), Mean ± SD	13.1 ± 8.2
Re-injury of medial meniscus with ACL re-injury, N (%)	1 (1.8 %)
Anterior cruciate ligament reconstruction failure, N (%)	3 (5.6 %)
Further surgery for exostosis removal, N (%)	2 (3.8 %)
Medial collateral ligament laxity, N (%)	2 (3.8 %)
Lateral meniscus white-white tears, N (%)	1 (1.8 %)

ACL: Anterior Cruciate Ligament; SD: Standard Deviation; N: Number of cases; %: Percentage.

excellent functional outcomes and high healing rates when performed with appropriate techniques.^{17–22} Moreover, the study highlighted the critical role of addressing rotational instability, often exacerbated by Ramp lesions, to optimize knee function and reduce failure rates.

The study demonstrated that rotational instability was present in 64.8 % of patients with Ramp lesions, as assessed via the pivot shift test. This finding emphasizes the role of Ramp lesions in exacerbating internal tibial rotation, which contributes to functional instability. Lateral extra-articular tenodesis was performed in 54.7 % of patients, particularly those with high functional demands. These results support prior studies that identified the relationship between Ramp lesions, increased rotational instability, and the necessity of lateral tenodesis to restore stability.^{23–25} Interestingly, the absence of lateral tenodesis in most suture failure cases in this study further corroborates its importance in preventing secondary meniscal injuries.^{17,26–28}

A significant challenge in Ramp lesion repair is achieving adequate visualization of the posterior horn of the medial meniscus. Several authors advocate for posteromedial portals to ensure optimal visualization and complete lesion closure.^{7,29–32} However, in this study, pie-crusting of the POL was employed to improve access through anterior portals, demonstrating its efficacy in achieving comparable healing rates to those reported with posteromedial techniques.^{33,34} Despite this, the study acknowledges findings from Thauunat et al. and Grousopoulos et al. which suggest higher failure rates for anterior portal repairs compared to posteromedial approaches.^{27,36} Ensuring proper visualization remains a critical factor in successful Ramp lesion repair.

The clinical outcomes of this study are consistent with prior research.^{20,22,28,35,36} Mean IKDC and Lysholm scores of 81.5 and 94.5 demonstrate significant functional recovery, with scores aligning with those reported in studies focused on the all-inside suture technique.^{20,28} The Tegner Activity Scale showed a modest decrease from 7.2 ± 1.2 preoperatively to 6.8 ± 1.3 postoperatively, consistent with reductions reported in similar studies.^{36–38} The high survivorship rate of 87.1 % aligns with the results of Chen et al. who reported an 87 % healing rate

using the Fast-Fix device through anterior portals.²²

The total failure rate in this study was 12.9 %, which is lower than the rates reported in the literature, ranging from 14.8 % to 19.1 %.^{39,40} Failures were primarily attributed to knee sprains during rehabilitation, persistent medial knee pain due to incomplete healing, and reinjuries after returning to sports. Notably, five of six failure cases did not involve lateral tenodesis, reinforcing its role in reducing secondary meniscectomy rates.²⁷ These findings highlight the importance of addressing rotational instability alongside Ramp lesion repair to minimize failure risks.

Complications in this study were infrequent but noteworthy. Two cases of chronic medial collateral ligament (MCL) injuries were described. In one case, the patient also experienced ACL reconstruction failure and Ramp lesion repair with significant valgus stress instability. In the other case, anteromedial instability was reported during follow-up despite an intact ACL and medial meniscus. Recent studies, such as that by Willinger et al. have demonstrated a close correlation between MCL injuries, Ramp lesions, and bone bruises, suggesting further investigation into the timing and management of MCL lesions in conjunction with Ramp repairs.⁴¹

The present study has notable strengths. First, it is one of the few studies to comprehensively evaluate Ramp lesion repair's clinical outcomes and survivorship using the all-inside technique through anterior arthroscopic portals. Second, all surgeries were performed by a single experienced surgeon, ensuring consistency in surgical technique and minimizing variability. Third, using standardized outcome measures, such as the IKDC and Lysholm scores and a detailed analysis of failure rates and complications, provides robust and clinically relevant data. Lastly, the study addresses an important and underexplored topic in orthopedic surgery, contributing valuable insights into managing Ramp lesions, particularly concerning optimizing rotational stability and visualizing lesions through anterior portals.

This study has several limitations that should be considered when interpreting the results. First, the study's retrospective nature and the absence of a control group limit the data analysis's robustness and the findings' generalizability. Second, the small sample size reduces the statistical power and the ability to detect subtle differences between patient subgroups. Future research should address these limitations by expanding the sample size and incorporating a control group to strengthen the conclusions. Additionally, a prospective database is currently being compiled, enabling further studies to validate the findings of this case series and explore the efficacy of different surgical techniques with greater statistical rigor.

5. Conclusion

The present study confirms that repairing Ramp lesions using the all-inside technique through anterior arthroscopic portals achieves excellent clinical outcomes and high rates of return to sport. The failure rate observed in this study was comparable to that of other established surgical techniques, including the posteromedial portal and trans-septal approaches. These findings highlight the reliability and efficacy of the anterior repair approach, particularly when combined with pie-crusting of the posterior oblique ligament, to optimize visualization and repair. However, further studies with larger prospective cohorts and control groups are needed to confirm these results and to deepen our understanding of Ramp lesion pathology and its optimal management.

CRedit authorship contribution statement

Antonio Clemente: Conceptualization, Writing – original draft. **Domenico Zaccari:** Writing – original draft, Data curation, Methodology, Investigation. **Federico Verdone:** Writing – original draft, Data curation, Methodology. **Glauco Loddio:** Investigation, Visualization. **Francesco Bosco:** Data curation, Visualization, Supervision. **Francesco Saccia:** Investigation, Visualization, Supervision.

Guardian/patient's consent

Not Applicable.

Ethical statement

The study was conducted following the ethical standards of the Declaration of Helsinki (1964).

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Declaration of competing interest

Francesco Saccia declares his role as a consultant for educational activities with Smith & Nephew and Medacta.

The corresponding author, on behalf of all other authors, confirms that no additional conflicts of interest exist.

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