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Good satisfaction and functional outcomes after arthroscopic debridement of Cyclops syndrome post-Anterior Cruciate Ligament reconstruction: Analysis of 197 patients of the MERIscience cohort

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Abstract

Purpose: The primary objective was to assess the clinical efficacy and patient satisfaction following arthrolysis for Cyclops syndrome postanterior cruciate ligament reconstruction (ACLr). The secondary objective was to compare clinical and functional outcomes in patients who underwent early and late arthroscopic debridement. We hypothesised that arthroscopic anterior arthrolysis for Cyclops syndrome post-ACLr leads to significant improvement in functional outcomes and patient satisfaction.

Methods: One hundred ninety-seven patients underwent arthroscopic anterior arthrolysis for Cyclops syndrome after primary ACLr between 1 January 2018 and 1 July 2024. The simple knee value (SKV), International Knee Documentation Committee (IKDC), return to sports after injury (RSI) score, Tegner score and time to return to sports (RTS) were assessed. Subgroup analyses were performed to compare early (≤6 months) versus late debridement (>6 months) and evaluate the impact of age and symptoms, using a linear and logistic regression analyses.

Results: 4.3% ($n = 197$) of our primary ACLr underwent an arthroscopic arthrolysis for Cyclops syndrome. One hundred eighty-two patients (92%) would repeat the anterior debridement. The mean SKV was 79.6 ± 16.4%, the mean IKDC score was 80.1 ± 13.3 and the mean RSI score was 62.7 ± 26.6. Younger age than 24.5 at ACLr was significantly associated with RTS to preinjury level following arthroscopic debridement of the Cyclops lesion ($p = 0.039$), and age younger than 29.5 years was significantly linked to resumption of running ($p = 0.001$). No statistically significant difference was found between early and late debridement when it came to RTS (6.9 ± 5.5 vs. 5.3 ± 4.4; $p = 0.10$) and functional scores (SKV 82.1 ± 10.6 vs. 79.0 ± 17.5; $p = 0.19$, IKDC 83.3 ± 11.1 vs. 79.3 ± 13.7; $p = 0.12$, RSI 67.4 ± 22.9 vs. 61.4 ± 27.4, $p = 0.23$).

Abbreviations: ACLr, anterior cruciate ligament reconstruction; ALL, antero-lateral ligament; AMI, arthrogenic muscle inhibition; BMI, body-mass Index; IKDC, International Knee Documentation Committee; ROC, receiver operating characteristic; RSI, return to sports after injury; RTS, return to sports; SKV, simple knee value; ST, semitendinosus.

Conclusion: Arthroscopic anterior arthrolysis for Cyclops syndrome post-ACLr is an effective and satisfactory procedure regardless of timing. Young population achieve superior functional recovery and RTS to preinjury level.

Level of Evidence: Level IV.

KEYWORDS
ACL, arthrolysis, cyclops, debridement, return to sport

INTRODUCTION

The Cyclops lesion, or localised anterior arthrofibrosis, was first described by Jackson and Schaefer in 1990 when they found a nodular fibrovascular tissue interposed in the intercondylar notch after anterior cruciate ligament reconstruction (ACLr) [3, 5, 11, 18, 27]. They associated it with what they called a Cyclops syndrome seeing that the lesion led to a loss of full knee extension [3, 18, 28, 38, 43]. It was labelled as such because of the arthroscopic appearance of the lesion, which has a head-like appearance with a red-blue discoloration that resembles the eye of a 'cyclops' [3, 21, 27, 50]. Reported with all types of graft [21, 50], the histology of these lesions consists of disorganised dense peripheral fibrous tissue with a central region of granulation tissue in all specimens, with or without cartilaginous and/or necrotic bone tissue [3, 21, 27, 28].

The literature is quite poor when it comes to Cyclops syndrome, with mostly case reports and case series [27]. Being the gold standard for this pathology, arthroscopic anterior arthrolysis is a fast and reliable method to debride the lesion [5, 27]. Since no large series of Cyclops syndrome have been reported so far in the literature, this study aims to evaluate a cohort of patients diagnosed with Cyclops syndrome to better understand the management of such lesions. The primary objective of this study was to assess the clinical efficacy and patient satisfaction following arthroscopic anterior arthrolysis in a large cohort of patients diagnosed with Cyclops syndrome post-ACLr. The secondary objective was to compare clinical and functional outcomes, as well as return to sports, between patients who underwent early (≤6 months post-ACLr) and late (>6 months) arthroscopic debridement, in order to better understand the impact of surgical timing on recovery and overall satisfaction. The hypothesis was that arthroscopic anterior arthrolysis for Cyclops syndrome post-ACLr led to significant improvement in functional outcomes and patient satisfaction. The secondary hypothesis was that early arthroscopic debridement (≤6 months post-ACLr) resulted in significantly better clinical and functional outcomes compared to late debridement (>6 months).

METHODS

Patient selection

This was an institutional board approved (IRB: CERC-VS-2024-10-3) retrospective study of prospectively collected data from the MERIscience Cohort of patients who underwent arthroscopic arthrolysis for Cyclops syndrome post-ACLr. The MERIscience cohort is a cohort including patients who underwent ACL reconstruction by three knee surgeons at our institution, with standardised collection of clinical, functional and return-to-sport data. All patients who underwent an ACLr from 1 January 2018 till 31 October 2023 were initially chosen from our cohort. Patients who underwent surgical management for a Cyclops syndrome with arthroscopic debridement between 1 January 2018 and 1 July 2024 were selected. Only patients who underwent primary ACLr and who developed subsequent Cyclops syndrome with symptomatic extension deficiency/flexion contracture (deficit of extension compared to full extension on the contralateral side [11]) were included, after obtaining their informed consent (or parents' consent for minors) in accordance with the ethical standards of the 1964 declaration of Helsinki. Adequate positioning of the femoral and tibial tunnels was also checked on control X-rays and/or post-ACLr MRIs [14]. Any tunnel mispositioning according to Osti et al. resulted in the exclusion of the subject from this study [39]. Other exclusion criteria were as follow:

- Other concomitant diagnosed knee pathology (e.g., osteoarthritis, inflammatory arthritis)
- Arthrolysis for mixed flexion and extension, which represents fibrotic healing instead of an evolution into a true Cyclops syndrome [27]
- Multiligamentous injuries.
- Algodystrophy [5, 38, 55]
- Additional surgical intervention unrelated to the debridement for the Cyclops syndrome (infection, re-rupture, contralateral rupture after the arthroscopic arthrolysis, secondary meniscectomy after the arthroscopic arthrolysis) [5]
- Patients lost to follow-up
- Arthrolysis after >2 years after the ACLr

The present article follows the STROBE (Strengthening The Reporting of Observational Studies in Epidemiology) reporting guidelines for observational studies [16] (Appendix S1).

Surgical technique and rehabilitation

Every ACLr in the Sports Clinic of Bordeaux-Mérignac was completed by using a 4-strand semitendinosus (ST) autograft, with or without an antero-lateral ligament (ALL) reconstruction using a two-strand Gracilis tendon graft [9]. When ALL reconstruction was warranted, but the Gracilis tendon could not be harvested or was of poor quality, a lateral tenodesis using the Fascia lata was performed. ALL reconstruction was performed when patients had one of the following criteria as per Sonnery-Cottet et al.: age < 25 years-old, a positive pivot shift test, performance of pivoting-type sports and high or competitive level of sports [19, 49].

When a patient was diagnosed with a symptomatic Cyclops lesion, an arthroscopic anterior arthrolysis was planned. This decision was decided and proposed to the patient once the general etiologies and other reasons for stiffness were excluded, with the presence of one of the following symptoms: lack of extension, swollen knee, stiffness and/or an audible or palpable clunk. In our practice, a discomfort in hyperextension without stiffness was also an indication. A minimum of 4 months between the primary surgery and the anterior arthrolysis was expected. The intercondylar notch was first inspected for the presence of a fibrous nodule that would confirm the diagnosis of Cyclops syndrome (Figure 1). Resection of the nodule as well as any adherence present in the anterior compartment with a shaver was achieved. Once the nodule was completely excised, the range of motion of the knee was checked to look for a full extension. If a residual lack of extension persisted, a plasty of the intercondylar notch using a high-speed burr was performed (Figure 2). Finally, both medial and lateral femoro-tibial compartments, as well as the integrity of both menisci or their healing status if repaired at the time of the initial procedure were verified. Partial debridement or suture of the meniscus would be done depending on the lesion type if present.

The postoperative protocol consisted of full weight-bearing with two crutches. If a meniscus was repaired, partial weightbearing for 45 days and limitation of knee flexion to 90 degrees for the first 6 weeks postoperatively was mandatory. Passive and active range of motion of the knee was highly stressed upon with special attention to avoid arthrogenic muscle inhibition (AMI).

Data collection

Demographic data such as height, weight, body-mass index (BMI), sex and the sports activity initially

FIGURE 1 Arthroscopic view from an antero-lateral portal in extension of the knee showing a Cyclops lesion (b) between the intercondylar femoral notch (a) and the tibia (c).

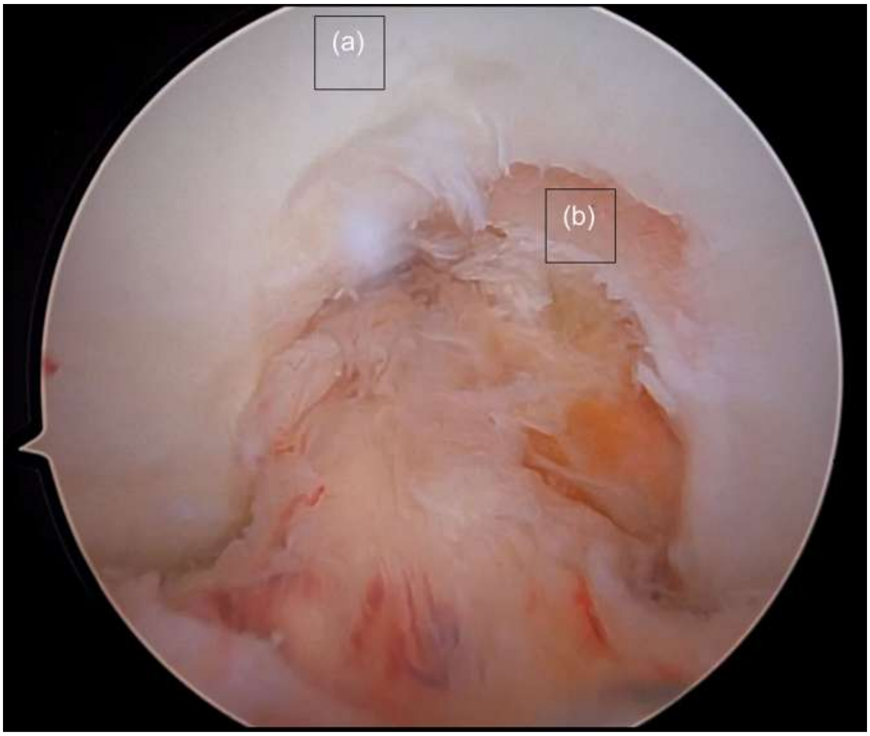

FIGURE 2 Arthroscopic view from an anterolateral portal of the knee in extension after the resection of the Cyclops lesion in the intercondylar femoral notch (a). Note the notchplasty with the high-speed burr in (b).

performed were gathered. Data regarding the initial ACLR intervention was collected: dates of the initial trauma and the primary ACLR, age at the time of surgery, side, graft type, external tenodesis procedure and presence or absence of a lateral and/or medial meniscal tear and whether they were debrided or repaired. The timing of the arthroscopic arthrolysis, the surgical time as well as the associated meniscal procedure (if any) were recorded. A subgroup analysis was performed to compare early (≤6 months) versus late debridement (>6 months). These cutoffs were chosen based on the studies of Eggeling et al. and Zhunussov et al. who showed that arthroscopic arthrolysis for arthrofibrosis of the knee had better postoperative range of motion and functional outcomes in patients who were debrided within 6 months of the index surgery [15, 59]. During the last follow-up after the arthroscopic arthrolysis, patients were interrogated to see if they resumed running, as well as the original sport they used to perform before the ACL injury. If they did, the level of return to sport compared to their original level (superior, same, inferior) was noted, in addition to how much time it took them to attain that level. If not, they specified the main reason. Postarthroscopic arthrolysis symptoms were checked for an asymmetry of extension in both knees (due to pain), stiffness (defined as a persistent limitation of knee extension that restricted full range of motion and impaired function, regardless of pain), effusion and clunk. Finally, patients reported outcomes scores (subjective International Knee Documentation Committee or IKDC [8], ACL-return to sports after injury or ACL-RSI [46], Simple knee value or SKV [31] and Tegner score [8]) were completed, and an answer to the following question was obtained: 'if you were to do it all over again, would you get operated on again of the arthroscopic arthrolysis?'.

Statistical analysis

Data were captured on an Excel spreadsheet, and SPSS (IBM SPSS Statistics, Version 25.0. IBM Corp.) was used to perform statistical analysis. Continuous variables were described as means ± standard deviations and categorical variables as numbers and percentages. A chi-square test was used for categorical variables, whereas a student's *t*-test was used for continuous variables. To control for potential confounders, both linear and logistic regression analyses were conducted. The distribution of continuous variables was evaluated using the Shapiro–Wilk test to assess normality. Additionally, a receiver operating characteristic (ROC) curve analysis was performed, and Youden's Index was calculated to identify the optimal age cutoff predictive of return to sport and return to running. The cutoff point for statistical significance was set at $p = 0.05$.

RESULTS

Demographic data

Between 1 January 2018 till 31 October 2023, a total of 4587 patients underwent ACLr in our centre, of whom 278 required arthroscopic arthrolysis for various reasons. After applying exclusion criteria, accounting to refusals and losses to follow-up, and excluding patients who underwent subsequent knee surgery, 197 patients remained eligible for inclusion, corresponding to a 4.3% prevalence of Cyclops syndrome following single-bundle ACLr. The flowchart in Figure 3 summarises the selection process.

The cohort had a mean age at ACLr of 26.3 ± 9.7 years, with a BMI of 24.3 ± 3.5 kg/m^2. One hundred and three patients were males (52.3%) and 94 were females (47.7%). In 87 cases, the left side was operated on (44.2%), with 110 cases for the right side (55.8%).

Prearthrolysis data

Table 1 summarises all the initial ACLr information. The mean time between injury and ACLr was 5.8 ± 16.9 months (0–159 months). All our initial surgeries were performed using hamstrings, with 194 using ST4 (98.5%) and three using ST and Gracilis (1.5%). A lateral tenodesis was performed in 130 patients, including 126 with anterolateral ligament (ALL) reconstruction (64%) and four with Fascia lata tenodesis (2%). Menisci were systematically evaluated, with no intervention required in 113 medial (57.4%) and 134 lateral (68%) menisci. Medial meniscal repair was performed in 79 patients (40.1%) and partial meniscectomy in 5 (2.5%), while the lateral meniscus was repaired in 34 patients (17.3%) and partially debrided in 22 (11.2%). The mean tibial tunnel diameter was 8.9 ± 0.8 mm (6–10.5 mm) and the mean femoral tunnel diameter was 8.6 ± 0.7 mm (7–10.5 mm). No other

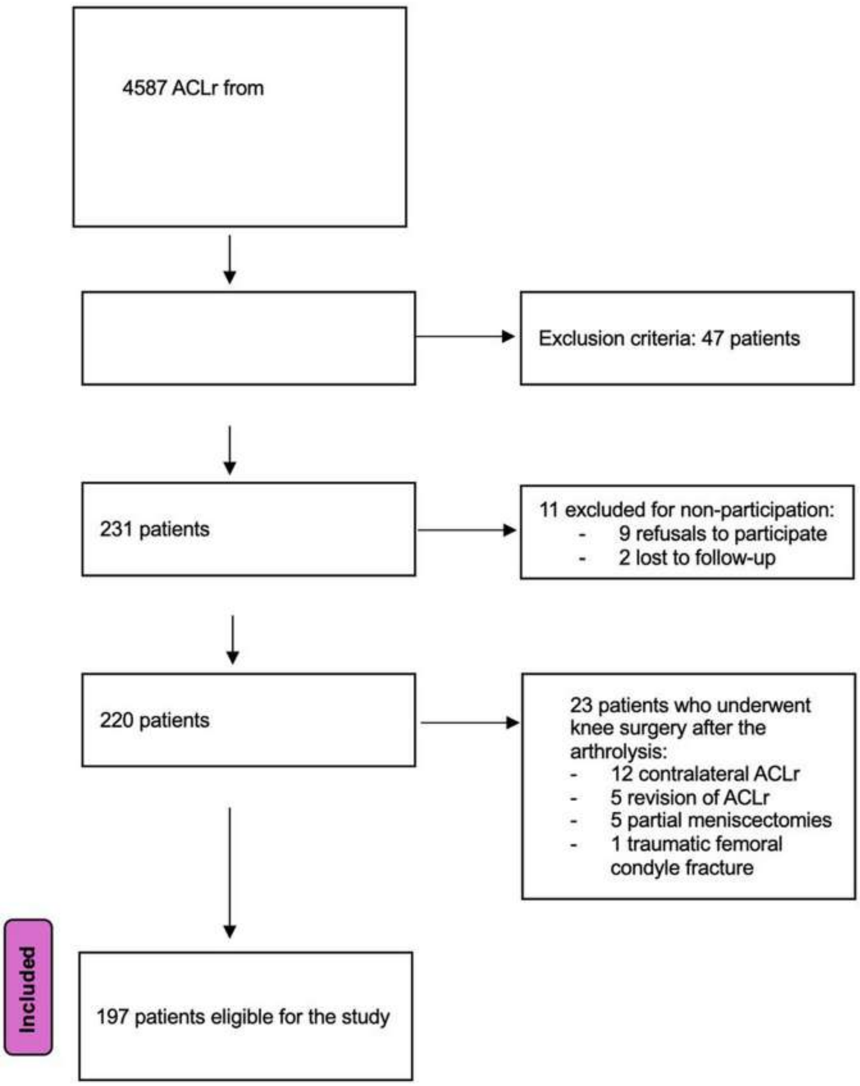

FIGURE 3 Flowchart of included and excluded patients for the study. ACLr, anterior cruciate ligament reconstruction.

TABLE 1 General information at initial ACL reconstruction.

Variable	Value
Age at ACL reconstruction	26.3 ± 9.7 years (13–58)
Body mass index (Kg/m^2)	24.3 ± 3.5 (17–36)
Sex	Male: 103 (52.3%)
	Female: 94 (47.7%)
Side of Injury	Left: 87 (44.2%)
	Right: 110 (55.8%)
Graft type	ST4: 194 (98.5%)
	STG: 3 (1.5%)
Lateral tenodesis	None: 67 (34%)
	FL: 4 (2.0%)
	ALL: 126 (64%)
Medial meniscus procedure	Nothing: 113 (57.4%)
	Suture: 79 (40.1%)
	Meniscectomy: 5 (2.5%)
Lateral meniscus procedure	Nothing: 134 (68.0%)
	Suture: 34 (17.3%)
	Meniscectomy: 22 (11.2%)
	Regularisation: 7 (3.6%)
Surgical delay	5.8 ± 16.9 months (0–159 months)
Tibial tunnel diameter	8.9 ± 0.8 mm (6–10.5 mm)
Femoral tunnel diameter	8.6 ± 0.7 mm (7–10.5 mm)

Abbreviations: ACL, anterior cruciate ligament; ALL, anterolateral ligament; FL, fascia lata; ST4, 4-strand Semi-tendinosus; STG, semi-tendinosus and gracilils.

concomitant surgical procedures aside from meniscus surgery and ALL reconstruction was performed.

Thirty seven patients (18.8%) were operated on for being uncomfortable during activities with absolutely no extension deficit depicted. Out of these 37 patients, four (2%) had no other symptoms whatsoever.

Postarthrolysis data

The mean operating time from the inflation of the tourniquet was 13.3 ± 4.9 min (5–44 min). The mean time between the ACL reconstruction and the arthroscopic arthrolysis was 8.9 ± 4.8 months (4–34 months). No statistical difference was found when comparing early arthrolysis (less than 6 months) versus late arthrolysis (more than 6 months) regarding the return to sports (RTS), functional scores, patients' satisfaction and postoperative symptoms (Table 2). When asked if they would repeat the same surgical management, 182 patients (92.4%) (n = 190) replied 'Yes', while seven patients didn't answer to the question. Concomitantly to the arthroscopic arthrolysis, we performed an additional act on one or both menisci in 30 patients, 20 (10.2%) of whom had partial meniscectomy while the other 10 (5.1%) had meniscal sutures. The mean follow-up after arthroscopic arthrolysis was 25.7 ± 19.5 months (6–73 months). The mean follow-up after the initial ACLr and the arthroscopic arthrolysis was 35 ± 20.7 months (9–84 months). One hundred fifty-seven patients (79.7%) returned to their initial sporting activities (compared to the ones they performed before the ACL injury), with the mean time after the arthroscopic arthrolysis of 5.7 ± 4.7 months (0.5–24 months). Seventy-two patients (36.5%) returned to their original sporting activities at the same level, while 52 patients (26.4%) had an inferior level and 18 patients (9.1%) had a superior level (Table 3). One hundred and seven patients (54.3%) were able to return to running after the arthroscopic arthrolysis. The mean Tegner score post-arthrolysis was 6.1 ± 2.1 (0–10; median = 6; inter-quartile range = 2).

As for the functional scores, we found a 79.6 ± 16.4% mean (0%–100%) for the SKV, an 80.1 ± 13.3 mean (36.78–100) for the IKDC score, and 62.7 ± 26.6 mean (0–100) for the ACL-RSI score.

After the arthroscopic arthrolysis and at the latest follow-up, 94 (47.7%) patients had an asymmetric extension with residual flexion of the knee. We found 50 (25.4%) patients with stiffness, 67 (34%) with clunk and 37 (18.8%) with knee effusion.

Postarthrolysis predictors

Using a logistic regression model (Table 4), we found a statistically significant relation between the age of the patient and all the following: the RTS (ORa = 0.96, $p = 0.04$, $R^2 = 0.11$), resumption of running (ORa = 0.95, $p = 0.001$, $R^2 = 0.19$) and a positive answer to the question 'if you were to do it all over again (ORa = 0.92, $p = 0.02$, $R^2 = 0.21$), would you get operated on again of the arthroscopic arthrolysis?'. By calculating a Youden′s index, we were able to identify an optimal cut-off age (at ACLr) of 24.5 for RTS and of 29.5 for resumption of running. No other relation was found when it came to other demographic data, pre- and postoperative symptoms, timing of surgical management and the presence of a meniscus act during the arthroscopic arthrolysis.

Using a linear regression model (Table 5), no statistically significant relation was found between timing of RTS and the previously mentioned parameters. However, we found that presence of postoperative symptoms was related to worse postoperative SKV ($\beta = -0.29$, $p < 0.001$, $R^2 = 0.14$), subjective IKDC ($\beta = -0.30$, $p < 0.001$, $R^2 = 0.21$) and Tegner scores ($\beta = -0.219$, $p = 0.003$, $R^2 = 0.21$). Finally, there was a

TABLE 2 Comparative results between early and late arthrolysis.

Variables	Early arthrolysis (<6 months) (*n* = 41)	Late arthrolysis (>6 months) (*n* = 156)	*p* value
RTS (months) mean ± SD	6.9 ± 5.5	5.3 ± 4.4	0.10
SKV mean ± SD	82.1 ± 10.6	79.0 ± 17.5	0.19
Tegner mean ± SD (median = 6; interquartile range = 2)	6.4 ± 1.6	6.0 ± 2.2	0.34
IKDC_SUBJECTIVE mean ± SD	83.3 ± 11.1	79.3 ± 13.7	0.12
ACL-RSI mean ± SD	67.4 ± 22.9	61.4 ± 27.4	0.23
RTS *n* (%)	35 (87.5%)	122 (79.2%)	0.24
Running *n* (%)	22 (55.0%)	85 (55.9%)	0.92
RTS level *n* (%)			
Inferior	8 (25.0%)	44 (40.0%)	
Same	18 (56.3%)	54 (49.1%)	0.23
Superior	6 (18.8%)	12 (10.9%)	
'Yes' answer for 'Would you repeat the arthrolysis' *n* (%)	38 (100%)	144 (94.7%)	0.15
Any postarthrolysis symptoms *n* (%)	30 (81.1%)	113 (75.8%)	0.50

Abbreviations: IKDC, International Knee Documentation Committee; RSI, return to sports after injury; RTS, return to sports; SD, standard deviation; SKV, simple knee value.

TABLE 3 Return to sports data.

Return to sports (RTS) metric	Value
Patients	157 (79.7%)
Time between arthrolysis and RTS	5.7 ± 4.7 months (0.5–24 months)
Level of sports after arthrolysis	Same: 72 (36.5%), Inferior: 52 (26.4%), Superior: 18 (9.1%)
Return to running	107 (54.3%)
Patients who returned to running and sports	94 (49.0%)
Patients who returned to neither	24 (12.5%)

TABLE 4 Logistic regression model for return to sports, running and satisfaction postarthrolysis.

Variable	Return to sport postarthrolysis odds ratio (*p* value)	Running postarthrolysis odds ratio (*p* value)	Willingness to repeat arthrolysis odds ratio (*p* value)
Body mass index (kg/m^2)	0.974 (0.649)	0.944 (0.242)	0.898 (0.304)
Sex	1.165 (0.711)	0.549 (0.076)	1.217 (0.811)
Age	0.962 (0.039)	0.945 (0.001)	0.923 (0.020)
Side	0.866 (0.725)	0.917 (0.797)	0.441 (0.360)
Preoperative symptoms	0.729 (0.153)	1.448 (0.051)	0.505 (0.125)
Time ACLr to arthrolysis	0.962 (0.313)	1.064 (0.084)	0.989 (0.904)
Meniscus act	0.926 (0.801)	0.792 (0.394)	1.161 (0.808)
Postoperative symptoms	0.386 (0.098)	0.605 (0.204)	0.585 (0.631)

Abbreviation: ACLr, anterior cruciate ligament reconstruction.

statistically significant relation between age and subjective IKDC ($\beta = -0.194$, $p = 0.008$, $R^2 = 0.21$) and Tegner ($\beta = -0.340$, $p < 0.001$, $R^2 = 0.21$) scores.

DISCUSSION

The most important finding of this study was that arthroscopic anterior arthrolysis for Cyclops syndrome post-ACL reconstruction was associated with high patient satisfaction (92% would repeat the procedure) and good functional outcomes (mean IKDC 80, SKV 79.6%). Younger patients were more likely to return to preinjury sport levels, while the timing of debridement (early vs. late) did not significantly influence outcomes.

We observed a prevalence of 4.3% ($n = 197$) of Cyclops syndrome after single-bundle ACLr in our institution. It has been reported in the literature that the incidence of the Cyclops syndrome varies between 1% and 11% [2, 6, 7, 10, 18, 26, 27, 32, 35, 38], whereas it was more common in double-bundle reconstruction, especially with Quadriceps graft [20, 27, 38, 50]. In fact, Sonnery-Cottet et al. [50] studied 387 patients who underwent a double-bundle ACL reconstruction, over a 1-year follow-up. They observed a more frequent Cyclops syndrome in Quadriceps grafts (5.37%) than with Hamstrings (1.99%), with an unlikely nodule from the roof of the intercondylar notch.

The ACLr technique that we adopt preserves the remnant of the native ACL. Some authors linked this technique to a higher complication rate of Cyclops syndrome. In their original work on Cyclops syndrome, Jackson and Schaefer advocated for a thorough debridement around the tibial tunnel as they linked the tissue that formed the cyclops nodule to the remaining tissue that stayed around the tunnel [26]. Delince et al. deducted that the stump of the nodule mainly arose from the base of the ACL graft, therefore suggesting it developed from the ACL stump left behind [12]. Finally, Wang and Ao linked the Cyclops lesions to inflammatory responses that would be caused by the ACL remnant [57]. However, many findings in the literature confirm that there is no difference between remnant-preserving and remnant-resecting ACLr in the development of Cyclops syndrome [1, 11, 21, 23, 27, 40, 42, 52, 56]. This is endorsed by the fact that the incidence of Cyclops syndrome in our institution falls within the accepted norms.

Beside the female sex and the double-bundle reconstruction of the ACL, other risk factors have been attributed to the development of Cyclops syndrome, like an anteriorly placed tibial tunnel, a narrow intercondylar notch, and persistent hamstring spasm in the context of an AMI [5, 18, 20, 27, 28, 38]. When the intercondylar notch is narrow, or the graft is large, an increased risk of graft notching can occur, ultimately leading to impingement and loss of extension [18]. In a

TABLE 5 Linear regression model for return to sports and functional outcomes.

Variable	Time to RTS standardised beta (p value)	SKV standardised beta (p value)	Tegner standardised beta (p value)	IKDC standardised beta (p value)	ACL-RSI standardised beta (p value)
Body mass index (kg/m^2)	0.107 (0.239)	−0.124 (0.109)	−0.001 (0.988)	−0.068 (0.368)	−0.164 (0.048)
Sex	−0.070 (0.416)	−0.033 (0.661)	−0.243 (0.001)	−0.100 (0.178)	−0.057 (0.481)
Age (to ACLr)	−0.128 (0.138)	−0.094 (0.204)	−0.340 (<0.001)	−0.194 (0.008)	−0.018 (0.817)
Side	0.020 (0.821)	−0.033 (0.661)	−0.016 (0.825)	−0.048 (0.520)	0.018 (0.821)
Time between ACLr and arthrolysis	−0.092 (0.276)	0.120 (0.100)	−0.005 (0.949)	−0.024 (0.738)	−0.050 (0.524)
Meniscus act during arthrolysis	0.088 (0.318)	0.000 (0.998)	0.059 (0.435)	−0.029 (0.702)	−0.124 (0.134)
Any post-op symptoms	0.010 (0.901)	−0.290 (<0.001)	−0.219 (0.003)	−0.302 (<0.001)	−0.112 (0.154)

Abbreviations: ACLr, anterior cruciate ligament reconstruction; IKDC, International Knee Documentation Committee; RSI, return to sports after injury; RTS, return to sport; SKV, simple knee value.

large cohort study, Delaloye et al. correlated the failure to regain full extension in the early postoperative period to a significant risk of developing Cyclops syndrome after ACLr [11]. This theory was endorsed by Pinto et al. who reported an increased risk of Cyclops syndrome in patients with extension deficits related to persistent hamstring contracture after ACLr [43].

Our patients were operated with an ACLr at a mean of 5.8 ± 16.9 months following the initial injury. There has been a lot of debate in the literature as to the timing of surgical intervention following an ACL injury [18, 20, 28, 36]. While some attributed the increased incidence of Cyclops syndrome to an early ACLr following injury [21, 22, 24, 47, 48, 51], others found no relationship [44] between the timing of the initial surgery and the development of extension loss [4, 25, 29, 30]. In a prospective randomised study, Von Essen et al. compared the outcomes of 33 acute ACLr within 8 days of injury to 35 delayed ACLr 6–10 weeks after injury [17]. They found no difference in the incidence of stiffness or altered range of motion between the two groups.

Once the ACLr has been done, any loss of knee extension for more than 2 months in spite of aggressive rehabilitation should alert us for a Cyclops syndrome [34]. In fact, about 93% of cases of Cyclops syndrome are diagnosed within 6 months of surgery [50], 78% of them having an extension loss within 6 weeks after surgery [27, 58]. Pinto et al. mainly attributed this extension loss to hamstring contracture, attributing a persistence of this contracture between 3 and 6 weeks after ACLr to an early predictive factor for the development of Cyclops syndrome [43]. This was even more corroborated by Delaloye et al. who reported that the risk of Cyclops syndrome was increased 8-fold in the case of an extension deficit at 6 weeks post-ACLr [11]. However, the development of a Cyclops lesion was shown to be independent from the time of ACLr to the initiation of rehabilitation therapy [20, 38, 57].

In our series, the mean time between the ACL reconstruction and the arthroscopic arthrolysis was of 8.9 ± 4.8 months. No clear cut-off in the literature has been reported as to the ideal time to operate a Cyclops syndrome post-ACLr. Tonin et al conveyed good results after excision of the lesion when performed within 12 weeks of presentation, without any recurrence after successful excision [54]. In a systematic review on incidence and risk factors of Cyclops syndrome following ACLr, Noailles et al. suggested that arthroscopic arthrolysis should be accomplished within 1 year after ACLr, with an appropriate rehabilitation program [38].

To our knowledge, there is no data in the literature that evaluated the RTS after an anterior arthrolysis for Cyclops syndrome, or that mentions the optimal timing of operating a Cyclops syndrome. We compared the return to sports of patients after early (less than 6 months) versus late (more than 6 months) arthroscopic arthrolysis and found no correlation between the timing of the arthroscopic arthrolysis and the RTS ($p = 0.10$). This suggests that arthroscopic arthrolysis remains a valuable option for restoring initial sporting activities (157 patients [79.7%] in our cohort), even when the diagnosis and subsequent intervention are delayed. With a mean Tegner score of 6.1 ± 2.1, we believe that arthroscopic arthrolysis is a good and valid option to help athletes return to their sporting activities at a decent level. Moreover, using a logistic regression model, we found a statistically significant relation between the age of the patient and both the RTS as well as the resumption of running, with an optimal cut off age (at ACLr) of 24.5 for RTS and of 29.5 for resumption of running. This should further incite us to systematically propose an anterior arthrolysis in this category of patients with a Cyclops syndrome.

After the arthroscopic arthrolysis, 94 (47.7%) patients had an asymmetric extension with residual flexion of the knee, 50 (25.4%) patients had stiffness, 67 (34%) had clunk and 37 (18.8%) had knee effusion. This contradicts the findings of Van Dijck et al. who claimed that symptoms completely resolve within a few weeks after the excision of the lesion, with a full range of motion gained [13]. This was another key point of this study: a lot of patients are not symptoms free after an anterior debridement for stiffness in extension. Regardless of the 94 patients (47.7%) with a persistent knee extension asymmetry, the mean SKV score was at 79.6%. We believe that this further suggests a multifactorial aetiology for loss of extension in the context of Cyclops syndrome, which was already suggested by Gohil et al. who found between 5° and 10° of loss of extension even with no evidence of Cyclops lesions on MRI [21]. A statistically significant correlation was found between the presence of postoperative symptoms and worse postoperative SKV, subjective IKDC (80.1 ± 13.3) and Tegner scores. By reducing the postoperative symptoms of anterior arthrolysis, we can then positively impact the satisfaction scores of the patients. Finally, there is a statistically significant correlation between a younger age (at ACLr) and better subjective-IKDC and Tegner scores, more validating the reason to operate younger patients with Cyclops syndrome with anterior arthroscopic arthrolysis.

When asked if they would repeat the same surgical management, 182 patients (92.4%) replied 'Yes'. There was also a correlation between a positive answer to this question and a younger age. We therefore recommend an arthroscopic arthrolysis to patients in which a Cyclops syndrome was diagnosed, or with a high suspicion of this pathology. The gold standard in the literature remains anterior arthrolysis by arthroscopy, which has led to favourable results [2, 12, 26, 27, 34, 38, 50, 57]. In order to prevent the development of knee degenerative lesions and loss of range of motion, early revision surgery with arthroscopic arthrolysis is warranted [33, 41, 45]. Nevertheless, the rates of reoperation to regain full extension after the development of Cyclops syndrome are still low (between 1.9% and 8.4%) [37, 43, 53, 57].

This study has several limitations. The data are retrospectively collected, which limits control over quality and may lead to information bias. Second, by failing to randomly assign patients to early or late arthroscopic debridement, we introduced a potential selection bias. Therefore, clinical decision-making regarding timing of intervention may have been influenced by unmeasured confounding factors like symptom severity or surgeon preference which in term impacts outcomes. The definition of early versus late debridement based on a 6-month postoperative threshold was based on two studies in which the etiologies of arthrofibrosis weren't specific to the Cyclops syndrome, which may not fully reflect the biological progression of Cyclops syndrome. Moreover, the follow-up duration varied among patients. This might have an influence on detecting long-term outcomes like recurrence, return to activity, and patient's satisfaction. Finally, there was no comparative group managed conservatively, which limits the power of this study to draw conclusions about the relative benefit of arthroscopic arthrolysis for Cyclops syndrome versus observation or rehabilitation alone.

CONCLUSION

Arthroscopic anterior arthrolysis for Cyclops syndrome post-ACLr is an effective intervention that leads to high rates of patient satisfaction and return to preinjury sporting activities. Surgeons should consider its indication even in delayed cases (beyond 6 months) when aiming to optimise functional recovery and return to sport. Patient age at time of ACLr emerged as a key prognostic factor, with patients younger than 24.5 years showing significantly higher rates of return to preinjury sports, and patients younger than 29.5 years showing significantly higher rates of running resumption. Future research should focus on determining better diagnostic criteria for this pathology and its role in surgical timing decision.

AUTHOR CONTRIBUTIONS

Writing original draft and editing: Jean Tarchichi. *Data curation and formal analysis*: Mohammad Daher and Baptiste Bouyge. *Writing review*: Nicolas Graveleau, Antoine Morvan and Pierre Laboudie, *Conceptualisation and writing review and editing*: Nicolas Bouguennec.

CONFLICT OF INTEREST STATEMENT

Nicolas Bouguennec is a consultant for SBM, Arthrex, Stryker and FH. Nicolas Graveleau is a consultant for SBM, Arthrex and FH.

DATA AVAILABILITY STATEMENT

The authors have nothing to report.

ETHICS STATEMENT

The study was approved by the Institutional Review Board of Vivalto Santé, France (Approval No. CERC-VS-2024-10-3). All patients consented to the use of their data with signed informed consent.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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