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Analysis of the efficacy of triple-channel minimally invasive knee arthroscopy in treating popliteal cysts in children

Yongwei Zhou^{1†}, Qining Yang^{1†}, Jiayu Kang¹ and Shan He^{2*}

Abstract

Background This study aimed to investigate a technique for treating pediatric popliteal cysts with a triple-channel knee arthroscopic approach, hypothesizing that this technique exhibits favorable clinical outcomes with reduced recurrence rates.

Methods A retrospective analysis was conducted on the clinical data of 14 patients with symptomatic pediatric popliteal cysts admitted to the joint surgery center using an arthroscopic minimally invasive technique from December 2017 to December 2020. Arthroscopy was employed for adequate enlargement of the posterior medial flap opening between the cyst and the joint cavity and to completely resect the cyst wall. The popliteal cyst recurrence was assessed through Magnetic Resonance Imaging (MRI) at 3 and 12 months post-surgery, and the Rauschning and Lindgren scores were recorded to evaluate the clinical prognosis.

Results A total of 14 children completed the follow-up, including 8 boys and 6 girls, with a mean age of 9.9 ± 1.1 years (5–12 years); 5 cases in the left knee and 9 cases in the right knee; the mean operative time was 19.2 ± 2.7 min (10–25 min); and the mean follow-up time was 15.1 ± 2.4 months (12–24 months). There was no intraoperative vascular or nerve injury and no incisional exudate infection. Postoperatively, posterior knee symptoms disappeared in the children, Rauschning and Lindgren scores significantly improved, and no recurrence signs were observed on MRI.

Conclusions This study determined that the arthroscopic three-channel minimally invasive technique is effective and safe for treating popliteal cysts in children, making it worthy of clinical promotion.

Keywords Popliteal cyst, Pediatric, Arthroscopy, Triple-channel

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Background

Popliteal cyst, the general term for synovial cyst in popliteal fossa, is a common knee joint disease. It was first systematically described by Baker in 1877. Popliteal cyst commonly occurs in the synovial sac of the medial head of the semimembranous and gastrocnemius muscles, often communicating with the joint cavity, and also known as Baker's cyst [1]. Popliteal cysts are more common in children than knee joints and have various treatment methods, with most being conservative; however, some patients still need surgical intervention [2–4]. With recent advancements in arthroscopic technology, numerous surgical techniques have been employed to treat popliteal cysts in adults, yielding satisfactory outcomes and an exceptionally low recurrence rate [5–7]. To the best of our knowledge, limited literature exists on the utilization of this minimally invasive treatment in children with popliteal cysts [8, 9]. Therefore, this study used a three-channel minimally invasive knee arthroscopy technique to treat popliteal cysts in children.

Method

Clinical data

This retrospective study was conducted using existing clinical data of 14 children with symptomatic, communicating popliteal cysts admitted to the Department of Joint Surgery of our hospital from December 2017 to December 2020. This study was approved by the Review Board of Jinhua Municipal Central Hospital. Patient-informed consent and ethical review were obtained because this study involved a retrospective analysis of existing imaging data.

All 14 patients had typical distending pain in the rear of the knee joint, along with limited knee bending, and magnetic resonance imaging (MRI) confirmed the presence of popliteal cysts (Fig. 1). Patient-informed consent

and ethical approval were obtained for this retrospective analysis of existing imaging data. All patients exhibited no significant improvement in symptoms after six months of conservative treatment. Therefore, all patients underwent three-channel minimally invasive knee arthroscopy to treat popliteal cysts, and the clinical efficacy was evaluated using the scoring criteria proposed by Rauschnig and Lindgren [10]. All procedures were performed by a single senior sports medicine physician.

Surgical methods

All patients were positioned supine under general anesthesia. Standard high anterolateral and anterolateral approaches were established, and routine arthroscopy and intraarticular inflammatory synovial clearance were performed. The arthroscope was introduced into the posterior compartment through the space between the medial side of the femoral medial condyle and the posterior cruciate ligament. A high posterior medial entrance was created from the outside to the inside through a lumbar puncture needle. Typically, the opening is located posteromedial to the medial head of the gastrocnemius, behind the plicae sac and the semimembranous muscle (Fig. 2). A high posteromedial approach was employed to excise a portion of the joint capsule using a planer. The capsule cavity was subsequently opened to introduce an arthroscope into the cavity under direct vision, and the capsule fold was cleared using a planer to expose the medial head of the gastrocnemius muscle (Fig. 2). A planer and radiofrequency ablation were then used to enlarge the valve opening and re-establish normal two-way channels. All procedures were performed on the posteromedial side of the medial head of the gastrocnemius muscle to avoid vascular and nerve damage.

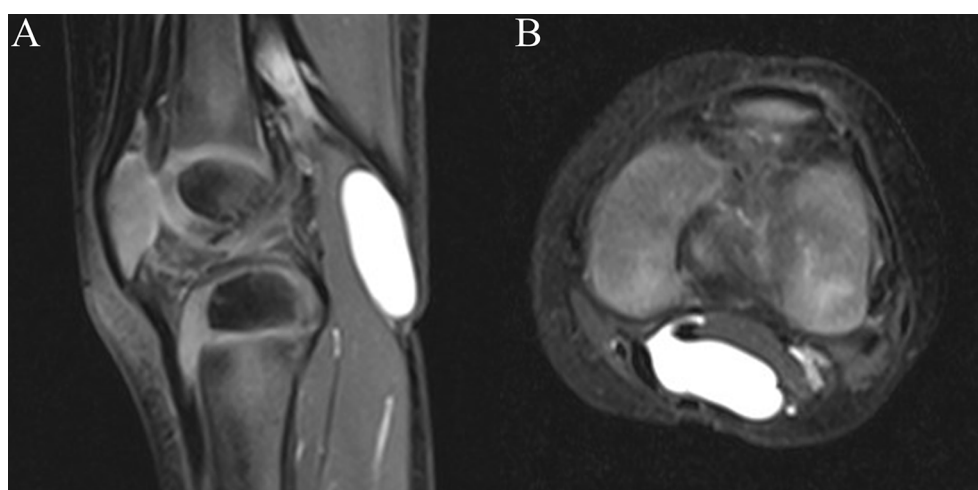


Fig. 1 (A) Sagittal MRI of popliteal cyst. (B) Cross-sectional MRI of popliteal cyst

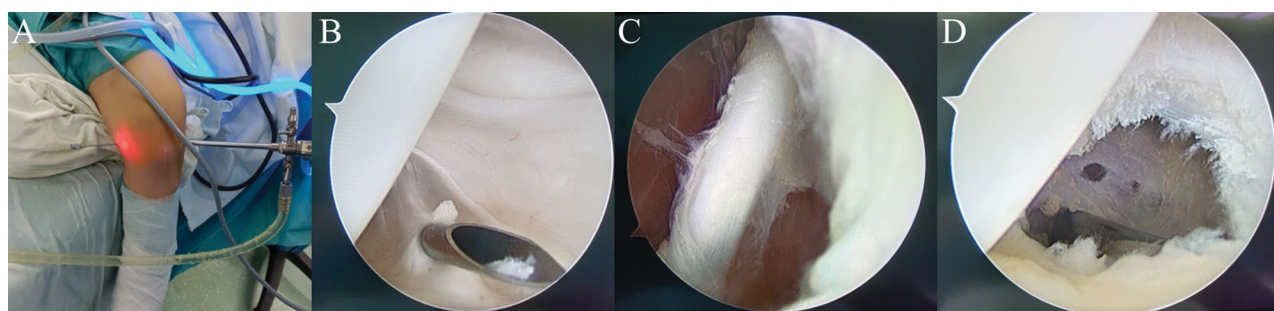


Fig. 2 (A) Arthroscope was inserted into the posteromedial compartment from between the PCL and medial epicondyle of the femur. (B) A lumbar puncture needle was inserted into the posteromedial space to create the posteromedial portal. (C) A shaver was inserted from posteromedial portal for expansion of the valvular structure to expose the medial head of the gastrocnemius. (D) The cyst valvular opening to expose and remove the inner cyst wall with the shaver

Table 1 Basic information of patients and clinical efficacy

Gender	Age (year)	Surgical spot	Duration of surgery (min)	Follow-up period (month)	Rauschnig and Lindgren grade		
					Preoperative	3 months after surgery	12 months after surgery
Male	10	Left	20	12	III	0	0
Female	9	Right	10	12	III	0	0
Male	8	Left	15	15	II	0	0
Male	5	Left	16	12	III	0	0
Female	10	Right	18	16	III	I	0
Male	12	Right	24	16	III	0	0
Male	11	Right	20	15	III	I	0
Female	10	Left	19	24	III	0	0
Female	11	Right	22	12	III	0	0
Male	9	Right	25	14	II	0	0
Female	12	Right	15	12	III	0	0
Male	9	Left	25	24	III	0	0
Male	10	Right	25	12	III	I	0
Female	12	Right	18	15	III	0	0
	9.9 ± 1.1	-	19.2 ± 2.7	15.1 ± 2.4	-	-	-

Postoperative treatment

The postoperative rehabilitation exercises were followed for all the patients under the supervision of rehabilitation specialists. Postoperative antibiotics are not required; only knee icing should be applied intermittently within 24 h post-surgery, and the knee joint can be actively moved and placed to the ground one day after surgery. Patients were discharged from the hospital 2–3 days post-surgery and progressively resumed their daily activities 2 weeks post-surgery. Regular postoperative outpatient follow-up was conducted. The clinical effects were assessed using Rauschnig and Lindgren scoring criteria at 3 and 12 months post-surgery.

Statistical analysis

IBM's Statistical Package for the Social Sciences software (version 21.0) was used for data processing. The Shapiro–Wilk test was utilized to determine whether

continuous variables followed a normal distribution. Data are presented as mean ± standard deviation ($\bar{x} \pm s$). The Chi-square test was employed for categorical data. P-values ≤ 0.05 were considered statistically significant.

Results

A total of 14 children were followed up, including 8 boys and 6 girls, with an average age of 9.9 ± 1.1 years (5–12 years). There were 5 cases of the left knee and 9 of the right knee; the mean operative time was 19.2 ± 2.7 min (10–25 min). The mean follow-up time was 15.1 ± 2.4 months (12–24 months; Table 1). During the surgery, there were no vascular and nerve injuries and no incisional fluid infection. After surgery, the posterior knee symptoms of the patients disappeared, and Rauschnig and Lindgren's scores significantly improved (Table 2). Moreover, no recurrence signs were observed on MRI in all cases.

Table 2 Rauschnig-Lindgren grade of patients

Grade	Preoperative (n)	3 months after surgery (n)	12 months after surgery (n)
0 grade	0	11	14
I grade	0	3	0
II grade	2	0	0
III grade	12	0	0

Discussion

Popliteal cysts, in children, are primarily asymptomatic cystic masses behind the knee joint. Compared with adults, popliteal cysts in children have a lower incidence of popliteal cysts, with unknown causes and a reported prevalence ranging from 2.4–6.3% [11]. However, popliteal cysts are highly prevalent (as high as 61%) in children with juvenile rheumatoid arthritis, which may be attributed to repeated fluid accumulation in the joints [12]. Children are most susceptible to popliteal cysts between 4 and 7 years of age. Most patients are asymptomatic and can be effectively treated using conservative methods, such as bracing, Nonsteroidal Antiinflammatory Drugs (NSAIDs), or intraarticular injection. However, studies have highlighted that the self-healing process of some cysts takes more than several years [13]. Moreover, some studies have indicated that surgical treatment is effective for patients with continuous cyst enlargement, peripheral vascular and nerve compression, or even cyst rupture [14]. The necessity of surgical treatment for popliteal cysts remains a topic of debate. Van et al. followed up 20 cysts in children. In the follow-up period, which ranged from 5 to 10 years, 14 cysts were treated conservatively, which eight had disappeared and six had shrunk [7]. However, some researchers have indicated that surgical intervention becomes essential when children experience uncomfortable symptoms [14, 15].

The symptoms commonly associated with cyst size include discomfort, distending pressure, and stiffness within either the posterior or posteromedial aspect of the knee joint. Upon physical examination, a resilient oval-shaped protrusion eliciting a wave-like sensation could be detected centrally or laterally within their posterior popliteal fossa region. Patients might encounter hyperextension-related discomfort closely linked to their range of motion. In a study by Bryan et al. involving 38 individuals afflicted with popliteal cysts, prevalent manifestations comprised distending pressure within the popliteal fossa (76%) and pain in the posteromedial knee joint (32%) [16]. A larger cyst leads to more pronounced constraints on knee extension and flexion post-physical exertion, particularly when compared to smaller counterparts.

Rauschnig also comprehensively described that the “fissure-like” structure formed by the medial head of the gastrocnemius and the semimembranous muscles was

like a valve [17]. During flexion, it opens due to the tension of the semimembrane tendon. During the extension process, the connection is closed due to the intersqueezing of the semimembranous muscle and the medial head of the gastrocnemius muscle. In response to the “valve mechanism” theory, some researchers [11, 18] intended to reduce the cyst recurrence by closing the valve opening with a valve suture. Lindgren et al. measured pressure within the joint cavity and the gastrocnemio-semimembranous bursa during normal knee flexion and extension [18]. This repair may not maintain normal pressure, which may contribute to the high recurrence rate of cysts in patients after valve closure repair.

In adults, with the development of arthroscopy technology, several studies have confirmed the effectiveness of minimally invasive knee arthroscopy technology in treating popliteal cysts, with a very low recurrence rate [19–21]. Adult popliteal cysts are believed to communicate with the knee joint (Fig. 3). However, there is ongoing debate regarding whether popliteal cysts in children are communicated with the joint lumen. Numerous studies have believed that popliteal cysts in children also communicate with the joint lumen [22, 23]. The accumulation of fluid in the joint lumen into the space of the gastrocnemius semi-membrane sac is the underlying cause of popliteal cysts in children. The arthroscopic surgical technique employed in the current study is established on this principle, which may provide an effective, minimally invasive treatment for popliteal cysts in pediatric patients while reducing the recurrence risk.

The capsular fold was removed intraoperatively in the present study, and the posteromedial valvular junction area was further expanded by at least 5 mm. This intervention was sufficient to transform the unidirectional flow between the joint cavity and the gastrocnemius-semimembrane sac into the normal bidirectional flow. The final follow-up results were satisfactory, without recurrence and postoperative complications in all patients.

A significant limitation of this study was the absence of a control group with open surgery and conservative treatment. Furthermore, the number of cases and the duration of follow-up were insufficient. Further controlled studies will be conducted with large numbers of cases and long-term follow-up to confirm the feasibility of this technique.

Conclusions

In summary, the arthroscopic three-channel minimally invasive technique for treating popliteal cysts in children is effective, safe, and worthy of clinical promotion.

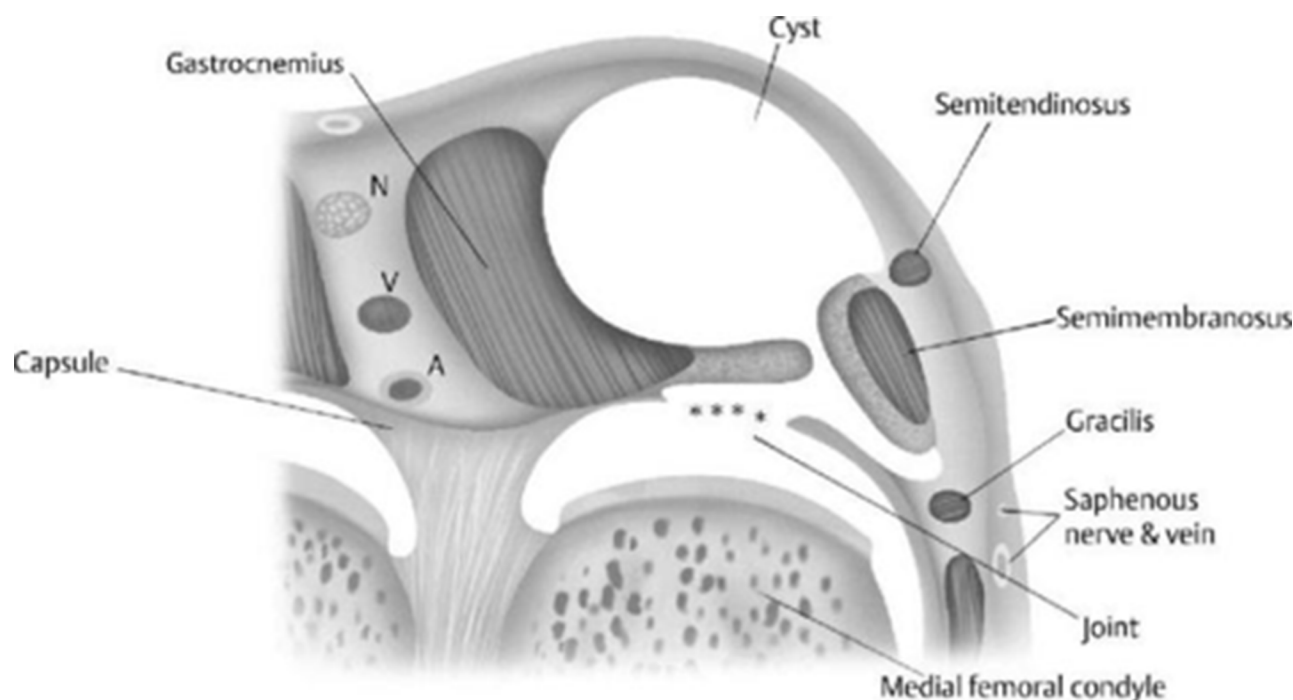


Fig. 3 Anatomical diagram of popliteal cyst

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Author contributions

Yongwei Zhou carried out the concepts, design, definition of intellectual content, literature search, data acquisition, data analysis, and manuscript preparation. Jiayu Kang provided assistance for data acquisition, data analysis, and statistical analysis. Yongwei Zhou and Qining Yang carried out literature search, data acquisition, and manuscript editing. Shan He performed manuscript review. All authors have read and approved the content of the manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Jinhua Municipal Central Hospital. All patients included in this study provided signed informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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