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Comparison of Percutaneous Versus Open Hamstring Lengthening in Patients of Spastic Diplegic Cerebral Palsy – A Randomized Controlled Trial

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Learning Point of the Article:

Percutaneous hamstring lengthening is as effective as open hamstring lengthening in improving knee function in children with spastic diplegic cerebral palsy, with potential advantages in muscle preservation and mobilization.

Abstract

Introduction: Cerebral palsy (CP) often manifests with crouch gait due to hamstring spasticity, necessitating surgical intervention like hamstring lengthening surgery. Percutaneous techniques are emerging as an alternative to traditional open approaches in orthopedic surgeries.

Objectives: This randomized controlled trial aimed to compare the outcomes of percutaneous hamstring lengthening (pHSL) versus open hamstring lengthening (oHSL) in pediatric patients with spastic diplegic CP, focusing on improvements in gait and knee function.

Materials and Methods: One hundred children diagnosed with spastic diplegic CP were randomized into pHSL (n = 50) and oHSL (n = 50) groups. Surgical procedures were performed using single-event multilevel surgery techniques. Pre-operative and post-operative assessments included range of motion, popliteal angle, gross motor function classification system (GMFCS) score, and gait analysis (functional independence measure [FIM], observational gait scale [OGS], physician gait scale). Statistical analyses were conducted using Statistical Packages for the Social Sciences v25.

Results: Both pHSL and oHSL groups showed significant improvements in popliteal angle and GMFCS scores postoperatively ($P < 0.001$ within each group). However, there were no significant differences between the groups in terms of these outcomes ($P > 0.05$). FIM, OGS, and physician gait scale also showed comparable improvements between groups ($P > 0.05$).

Conclusion: pHSL is as effective as oHSL in improving gait and knee function in pediatric patients with spastic diplegic CP. The percutaneous approach offers a safe and efficient alternative to traditional open surgery, potentially minimizing muscle damage and promoting quicker recovery.

Keywords: Cerebral palsy, hamstring lengthening surgery, percutaneous surgery, gait analysis, pediatric orthopedics.

Introduction

Cerebral Palsy (CP) is a non-progressive condition impacting movement and posture, stemming from early brain development injury [1]. It represents the most prevalent cause of enduring motor impairment, with an estimated prevalence of 3.3 per 1000 live births in the United States [2]. Individuals with CP commonly experience crouch gait, attributed to hamstrings' spasticity, contractures, and diminished hip and knee extensor strength [3,4]. Surgical hamstrings lengthening is frequently conducted to address crouch gait. Previous research indicates that hamstring lengthening surgery (HLS) can enhance knee extension static and dynamic range of motion (ROM)[5,6]. Specifically, studies involving children with CP have

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Table 1: Baseline characteristics among two groups

Demographic details	Group A oHLS (n=50)	Group B pHLS (n=50)
Age (mean) (SD) (years)	10.2±1.6	9.5±1.8
Age range (years)	5–18	6–18
Sex		
Male	18 (36%)	20 (40%)
Female	32 (64%)	30 (60%)
BMI (kg/m2)	17.4	17.1
GMFCS		
I	6 (12%)	8 (16%)
II	18 (36%)	14 (28%)
III	19 (38%)	18 (36%)
IV	6 (12%)	6 (12%)
V	1 (2%)	4 (8%)
GAIT		
Crouch	20 (40%)	16 (32%)
Jumper	14 (28%)	19 (38%)
Scissoring	16 (32%)	15 (30%)

BMI: Body mass index, oHLS: Open hamstring lengthening surgery, pHLS: Percutaneous hamstring lengthening surgery, GMFCS: Gross motor function classification system

demonstrated advancements in knee extension during initial contact and throughout the stance phase of the gait cycle post-HLS [7,8]. HLS encompasses diverse types, including medial and/or lateral hamstrings lengthening, with some patients necessitating supplementary procedures such as rectus femoris transfers, iliopsoas lengthening, and bony surgeries [9].

In contemporary orthopaedics, percutaneous surgical methods have increasingly emerged as a viable alternative to traditional open approaches. Studies have indicated that percutaneous hamstring lengthening surgery (pHLS) offer advantages in terms of maximizing muscle strength preservation and facilitating rapid mobilization compared to open techniques [10-12]. Though open hamstring lengthening surgery (oHLS) has been extensively explored, the available literature on the efficacy of percutaneous hamstring lengthening surgery (pHLS) in cerebral palsy (CP) patients remains limited. A study by Gordon et al. reported improvements in long-term dynamic gait parameters in children with CP following percutaneous medial HLS; however, a comparable group that underwent open lengthening was not included for assessment [8].

The effectiveness of pHLS compared to oHLS in improving crouch gait and knee function is uncertain. Therefore, our study was designed to assess the influence of open versus pHSL on knee movements in paediatric patients with cerebral palsy (CP). Specifically, our study involved a comparison of alterations in the popliteal angle, GMFCS (Gross Motor Function Classification System) grade [13], functional independence measure (FIM) [14], observational gait scale (OGS) [15], and physician rating scale (PRS) [16].

Materials and Methods

This study was a randomized controlled trial conducted at a

Table 2: - Comparison of popliteal angle and GMFCS values among two groups.

Popliteal angle	Group A oHLS (n=50)			Group B pHLS (n=50)			Statistical analysis
	Pre-operative (mean)	Post-operative (mean)	P-value within	Pre-operative (mean)	Post-operative (mean)	P-value within	P-value between groups
	65.2	29.4	<0.001	68.3	32.1	<0.001	0.84
GMFCS							
I	6	15		8	16		
II	18	26		14	24		
III	19	8		18	8		
IV	6	1	<0.001	6	2	<0.001	0.86
V	1	0		4	0		

	GROUP A			GROUP B			Statistical Analysis
	oHLS (n=50)			pHLS (n=50)			
	Pre-operative (mean)	Post-operative (mean)	P-value within	Pre-operative (mean)	Post-operative (mean)	P-value within	P-value between groups
Functional indepence measure (FIM)	48.4	78.6	<0.001	45.4	76.72	<0.001	0.79
Observational gait scale (OGS)	13	18	<0.001	12	17	<0.001	0.85
Physician rating scale (PRS)	4	7	<0.001	3	8	<0.001	0.82

Table 3: - Comparison of GAIT analysis parameters among two groups.

tertiary centre and approved by the institutional research ethics board. Gait analysis and clinical data were collected for 100 children with spastic diplegic cerebral palsy (CP) exhibiting crouch, jumping, or scissor gait (flexed knee gait). These patients underwent surgical hamstring lengthening using the single event multilevel surgery technique, which was performed by a single surgeon. All patients had spastic diplegia affecting both lower limbs to a similar extent.

The study encompasses patients aged up to 18 years diagnosed with spastic diplegic cerebral palsy (CP), demonstrating dynamic contractures resulting in crouch/jump gait, and presenting with moderate or severe spasticity (Ashworth Scale scores 3 and 4), subject to their provision of consent. However, exclusion criteria encompass patients with static/bony contractures, other forms of cerebral palsy, a history of prior fracture/dislocation, or contractures developed due to secondary causes such as burns.

All patients diagnosed with spastic diplegic cerebral palsy (CP) who presented at the outpatient department and met the predefined inclusion criteria were enrolled in the study. The patients were randomly divided into two groups using the Excel random number technique. Group A underwent percutaneous hamstring lengthening (pHLS), whereas Group B underwent open hamstring lengthening (oHLS). In both groups, treatment commenced with medial hamstring release, involving the semitendinosus and gracilis muscles, with or without semimembranosus release. For Group A, all procedures were conducted with the patient in the supine position. The tendinous portion of the semitendinosus was percutaneously tenotomised along with the gracilis. If the knee extension did not reach at least 20 degrees, partial tenotomy of the semimembranosus was performed. Conversely, patients in Group B underwent procedures in the prone position. The midline posterior approach was utilized, and classic Z-lengthening of the hamstrings was performed.

Bilateral above-knee casts, with the knee in full extension, were applied and maintained for a duration of six weeks. Patients were permitted to bear weight as tolerated immediately after removal of cast. Preoperatively and postoperatively at 1 year follow-up, all patients underwent evaluation to assess range of motion, popliteal angle, GMFCS score, and gait analysis using Functional indepence measure (FIM), Observational gait scale (OGS) and Physician rating scale (PRS).

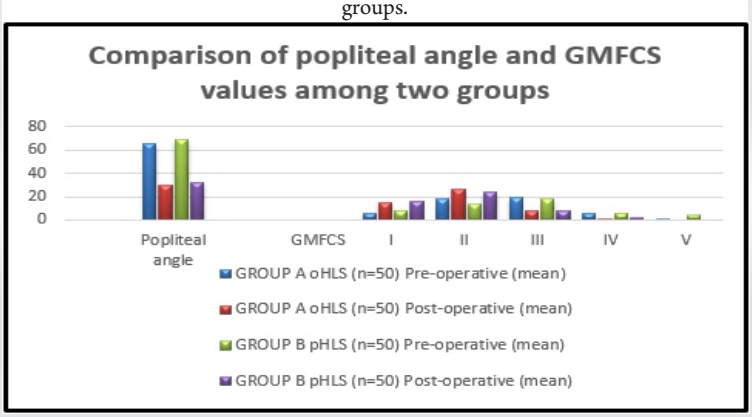
Statistical analyses were conducted utilizing SPSS v25 (IBM Corp, Armonk, NY, USA). Outcome variables were compared both within and between groups, using paired T-tests. The chi-square test was utilized to examine the relationship between continuous and categorical variables. Notably, a P-value less than 0.05 denoted statistical significance.

Results

The mean ages of the participants at the time of surgery were 10.2±1.6 years (range: 5-18 years) and 9.5±1.8 years (range: 6-18 years) for the open and percutaneous groups, respectively. Both groups exhibited a female predominance, with 64% in group I and 60% in group II. Other characteristics, including BMI, GMFCS score, and type of gait, demonstrated similarities between the two groups preoperatively (refer to Table 1). A significant difference was noted within each group (P value <0.001) in terms of popliteal angle improvement. However, such significance was not observed when comparing between groups (P value: 0.84). The GMFCS score within each group showed significant improvement (P < 0.001). Nevertheless, such significance was not observed when comparing between groups (P value: 0.86) (refer to Table 2 and Fig. 1).

Functional Independence Measure (FIM), Observational Gait Scale (OGS), and Physician Rating Scale (PrS) also revealed no

Figure 1:- Comparison of popliteal angle and GMFCS values among two groups.



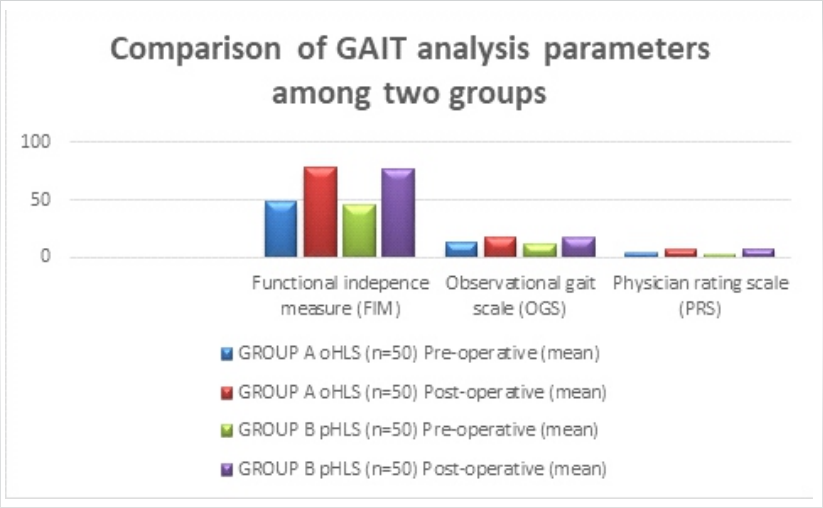


Figure 2: Comparison of GAIT analysis parameters among two groups.

significant differences between the two groups (refer to Table 3 and Fig. 2).

Discussion

Hamstring lengthening surgery is a crucial operative intervention for addressing spastic cerebral palsy (CP). This procedure can significantly enhance the gait, posture, and functional abilities of ambulatory children with spastic CP [17]. Moreover, it has demonstrated effectiveness in improving posture and activities of daily living for non-ambulatory CP patients. It is noteworthy that the percutaneous technique, when meticulously executed in the tendinous segment of the muscles by a proficient surgeon, has been proven to be safe and efficacious [17]. In our study, it was observed that the correction of the popliteal angle in the percutaneous hamstring lengthening (pHLS) subgroup corresponded with that of the open hamstring lengthening (oHLS) subgroup. Additionally, comparable changes in Gross Motor Function Classification System (GMFCS) and GAIT analysis parametres were identified in both subgroups.

Khaje Mozafari et al. conducted a study involving 54 patients and concluded that Percutaneous Hamstring Lengthening (HSL) is a safe, efficient, and expeditious procedure that yields outcomes comparable to those of the open technique for pediatric spastic diplegia. This aligns with the results obtained in our own study [17]. Another study by Alexander et al. reviewed 87 patients with cerebral palsy (CP) who underwent open or percutaneous HSL procedures, finding no significant disparity between the groups in terms of ultimate popliteal angle and knee kinematics, which is consistent with our findings [18].

Mansour et al. conducted a prospective randomized controlled trial comparing open versus percutaneous hamstring lengthening. The study, which encompassed 18 patients, yielded the finding that both open and percutaneous hamstring lengthening produced significant enhancements in popliteal angle in children with cerebral palsy. Nevertheless, the percutaneous technique led to unacceptable muscle damage and lesser improvement in knee extension [19]. In contrast, our study reveals similar outcomes across both techniques.

Our study holds a unique position in the current literature, as only one prospective comparative study has been published thus far, and it was based on a very small sample size. Therefore, our study has the potential to lay the groundwork for further research in this area. It is important to note that our study is limited by its single-center nature and a relatively brief follow-up period.

Conclusion

The study findings indicate that percutaneous hamstring lengthening represents a safe, straightforward, and efficient procedure for children with spastic diplegic cerebral palsy. The procedure's effectiveness mirrors that of the open technique, demonstrating its viability as an alternative approach in this population.

Clinical Message

CP leads to persistent motor impairments like crouch gait, often necessitating HLS. This study compared percutaneous (pHLS) versus oHLS techniques in 100 children with spastic diplegic CP. Both methods significantly improved popliteal angle and GMFCS scores within groups, with no significant difference between pHLS and oHLS outcomes. Functional measures (FIM, OGS, PRS) also showed comparable results. The findings support pHLS as a safe and effective alternative to oHLS, providing clinicians with a viable option for managing CP-related gait abnormalities. Further research is warranted to validate these results across diverse clinical settings and long-term follow-up periods.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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