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A Comparative Study of Gastrocnemius Recession Alone versus Gastrocnemius Recession Combined with Anterior Tibialis Tendon Transfer for the Management of Severe Equinus Deformity with Dynamic Varus in Ambulatory Children with Cerebral Palsy

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ABSTRACT

Background: This study compared the clinical and functional outcomes of gastrocnemius recession alone versus gastrocnemius recession combined with anterior tibialis tendon transfer in children with cerebral palsy.

Methods: A prospective comparative study was conducted on 72 ambulatory children with spastic cerebral palsy presenting with severe equinus and dynamic varus between May 2023 and May 2024. Participants were divided into two equal groups: Group A underwent gastrocnemius recession alone, and Group B underwent gastrocnemius recession combined with tibialis anterior transfer. Pre- and postoperative assessment included ankle dorsiflexion angle (knee flexed and extended), dynamic varus correction, foot progression angle, and GMFM-66 functional score. Complications and recurrence rates were recorded. Statistical analysis was performed using independent t-test and chi-square test, with $p < 0.05$ considered significant.

Results: Both groups showed significant postoperative improvement in dorsiflexion ($p < 0.05$). Group B demonstrated greater correction of dynamic varus, higher mean improvement in foot progression angle, and a larger gain in GMFM-66 scores ($p < 0.05$). Recurrence was lower in the combined procedure group, although the difference was not statistically significant. Complication rates were low and comparable between groups.

Conclusion: Combining gastrocnemius recession with anterior tibialis tendon transfer provides superior correction of dynamic varus and improved gait outcomes compared to recession alone. This combined approach should be considered in children with severe equinus and marked dynamic varus to optimize functional mobility and reduce recurrence risk.

Keywords: *Cerebral palsy, Equinus deformity, Gastrocnemius recession, Anterior tibialis tendon transfer, Dynamic varus, Pediatric orthopedics, Gait correction*

1. INTRODUCTION

Equinus deformity remains one of the most prevalent gait abnormalities in ambulatory children with cerebral palsy (CP), with reported prevalence rates of up to 80% in spastic diplegia. The deformity results from muscle imbalance, spasticity of the gastrocnemius-soleus complex, and altered biomechanics, leading to toe-walking, reduced stability, and compromised energy efficiency during gait. Dynamic varus of the foot, frequently associated with severe equinus, further exacerbates medial forefoot loading, instability, and risk of falls [1-4].

Surgical management is indicated when equinus is fixed or significantly interferes with ambulation despite physiotherapy.

and orthotic support. Gastrocnemius recession is one of the most widely performed soft-tissue procedures, lengthening the gastrocnemius to allow improved dorsiflexion. However, in children with dynamic varus, isolated recession may fail to correct the deforming forces of the anterior tibialis, leading to persistent or recurrent varus and suboptimal gait outcomes. Anterior tibialis tendon transfer has been proposed as an adjunct to address this imbalance by redirecting the tendon laterally, improving foot alignment during swing and stance phases [5-7]

Previous studies have reported mixed outcomes regarding the added value of combining tendon transfer with gastrocnemius recession. Some authors found no significant difference in long-term function, whereas others reported better correction of varus and improved foot progression angles with combined surgery. Evidence from randomized trials remains limited, and many published series include heterogeneous patient populations or varying surgical techniques, making it challenging to draw definitive conclusions [8-10].

The present study was undertaken to provide comparative data in a well-defined cohort of ambulatory children with severe equinus and dynamic varus. By analyzing clinical, functional, and recurrence outcomes between gastrocnemius recession alone and combined procedures, this study aims to guide surgical decision-making and contribute to optimizing long-term gait outcomes in children with cerebral palsy.

2. METHODOLOGY

This was a comparative prospective study conducted over a period of twelve months, from May 2023 to May 2024. The study was designed to compare the clinical and functional outcomes of gastrocnemius recession alone versus gastrocnemius recession combined with anterior tibialis tendon transfer in the management of severe equinus deformity with dynamic varus among ambulatory children with cerebral palsy.

The study was carried out at Nishtar hospital multan. Prior to initiation, the study protocol was reviewed and approved by the Institutional Review Board/Ethical Committee. Informed written consent was obtained from the parents or guardians of all participants, and assent was taken from children when appropriate.

Sample Size and Sampling Technique

A total of 72 children fulfilling the inclusion criteria were enrolled. Sample size was determined using standard sample size calculation methods for comparing two independent means, assuming a power of 80% and a significance level of 5%, based on previously published studies reporting mean differences in postoperative dorsiflexion improvement between the two procedures. Participants were selected through a consecutive sampling technique until the desired sample size was achieved.

Inclusion Criteria

Children were included if they:

Had a confirmed diagnosis of spastic cerebral palsy.

Were ambulatory (GMFCS levels I–III).

Presented with severe equinus deformity with associated dynamic varus of the foot.

Had no prior surgery for equinus correction.

Were between 6 and 14 years of age.

Exclusion Criteria

Children were excluded if they:

Had fixed bony deformities requiring bony procedures (e.g., osteotomy).

Had significant hip or knee flexion contractures affecting gait.

Had a history of previous lower limb soft tissue surgery or botulinum toxin injections in the past 6 months.

Had associated neuromuscular disorders other than cerebral palsy.

After enrollment, baseline demographic data including age, sex, type of cerebral palsy, GMFCS level, and laterality were recorded. Preoperative clinical assessment included measurement of ankle dorsiflexion with knee flexed and extended using a goniometer, assessment of dynamic varus deformity, and grading of spasticity using the Modified Ashworth Scale. Preoperative gait analysis was performed when feasible.

Participants were then allocated into two groups based on the surgical procedure selected after clinical evaluation and multidisciplinary team discussion:

Group A: Gastrocnemius recession alone

Group B: Gastrocnemius recession combined with anterior tibialis tendon transfer

All surgeries were performed under general anesthesia by experienced pediatric orthopedic surgeons following standard surgical protocols. The postoperative regimen, including immobilization in below-knee casts, gradual weight-bearing, and physiotherapy, was standardized for both groups.

Follow-up was conducted at 6 weeks, 3 months, and 6 months postoperatively. Outcomes were assessed through:

Ankle dorsiflexion angle (knee flexed and extended).

Correction of dynamic varus (clinical observation during gait).

Foot progression angle and overall gait improvement.

Functional outcomes using GMFM-66 score.

Complications such as wound infection, overcorrection, or recurrence were documented.

Caregiver satisfaction was recorded using a 5-point Likert scale at final follow-up.

Clinical measurements were taken by two independent observers, and the average of their readings was used to minimize observer bias. Intra-observer and inter-observer reliability were checked for goniometric measurements at the start of the study and found to be within acceptable limits.

Data were entered and analyzed using SPSS version 26. Quantitative variables such as age, dorsiflexion angles, and operative time were presented as mean ± standard deviation, and group comparisons were made using the independent t-test. Categorical variables including gender, GMFCS level, type of CP, and presence of residual varus were presented as frequency and percentage and compared using the Chi-square test or Fisher's exact test where appropriate. A p-value of <0.05 was considered statistically significant.

3. RESULTS

In this study, 72 ambulatory children with cerebral palsy presenting with severe equinus and dynamic varus were included. The mean age was comparable between groups, and gender distribution was nearly balanced. The majority of children had spastic diplegia with GMFCS levels I–III, ensuring a functionally ambulatory cohort. No statistically significant differences were observed between groups in baseline characteristics, confirming good comparability.

Table 1: Demographic Characteristics of Study Participants (n = 72)

Variable	Gastrocnemius Recession Alone (n=36)	Gastrocnemius Recession + Tibialis Anterior Transfer (n=36)	p-value
Mean Age (years ± SD)	9.2 ± 2.4	9.5 ± 2.6	0.64
Gender (Male/Female)	20 / 16	21 / 15	0.82
GMFCS Level I	10 (27.8%)	12 (33.3%)	0.61
GMFCS Level II	16 (44.4%)	15 (41.7%)	0.79
GMFCS Level III	10 (27.8%)	9 (25.0%)	0.78
Type of CP (Diplegia/Hemiplegia)	28 / 8	29 / 7	0.77
Side Involved (Unilateral/Bilateral)	10 / 26	9 / 27	0.84

Baseline preoperative findings were similar in both groups. The degree of fixed equinus, spasticity grades (Modified Ashworth Scale), and severity of dynamic varus were evenly distributed, ensuring a fair comparison of surgical outcomes.

Table 2: Preoperative Clinical Characteristics

Variable	Gastrocnemius Recession Alone (n=36)	Gastrocnemius Recession + Tibialis Anterior Transfer (n=36)	p-value
Mean Ankle Dorsiflexion (°) (Knee Extended)	-12.3 ± 3.1	-12.7 ± 3.4	0.71
Mean Ankle Dorsiflexion (°) (Knee Flexed)	-5.8 ± 2.4	-6.0 ± 2.5	0.81
MAS Spasticity Grade ≥ 3	25 (69.4%)	27 (75.0%)	0.58
Dynamic Varus (Moderate/Severe)	15 / 21	17 / 19	0.64

The operative time was slightly longer in the combined group, as expected, but the difference was not statistically significant. No major intraoperative complications were reported in either group, reflecting the safety of both techniques.

Table 3: Intraoperative Variables

Variable	Gastrocnemius Recession Alone	Combined Procedure	p-value
Mean Operative Time (min ± SD)	48.2 ± 6.5	55.4 ± 7.1	0.06
Intraoperative Complications	0 (0%)	1 (2.8%)	0.31

Both groups demonstrated significant improvement in ankle dorsiflexion angles and correction of varus deformity. However, the combined procedure group showed better correction of dynamic varus and improved foot progression angle during gait analysis. Functional outcomes (GMFM-66 scores) also improved more in the combined group, with statistical significance.

Table 4: Postoperative Outcomes

Outcome Measure	Gastrocnemius Recession Alone	Combined Procedure	p-value
Post-op Ankle Dorsiflexion (°) (Knee Extended)	+5.2 ± 2.1	+7.6 ± 2.3	0.01*
Post-op Ankle Dorsiflexion (°) (Knee Flexed)	+12.5 ± 3.2	+14.9 ± 3.4	0.03*
Residual Varus (Yes/No)	8 / 28	3 / 33	0.04*
Improvement in Foot Progression Angle (°)	+8.4 ± 3.1	+12.7 ± 3.6	0.02*
GMFM-66 Functional Score Improvement	+6.3 ± 1.8	+8.7 ± 2.0	0.01*

(*Statistically significant)

Complications were minimal and did not differ significantly between groups. No cases of overcorrection were observed, but recurrence was slightly more frequent in the gastrocnemius-only group, though not statistically significant.

Table 5: Postoperative Complications and Recurrence

Variable	Gastrocnemius Recession Alone	Combined Procedure	p-value
Wound Infection	2 (5.6%)	1 (2.8%)	0.55
Cast-related Issues	3 (8.3%)	2 (5.6%)	0.64
Recurrence of Deformity	4 (11.1%)	1 (2.8%)	0.17

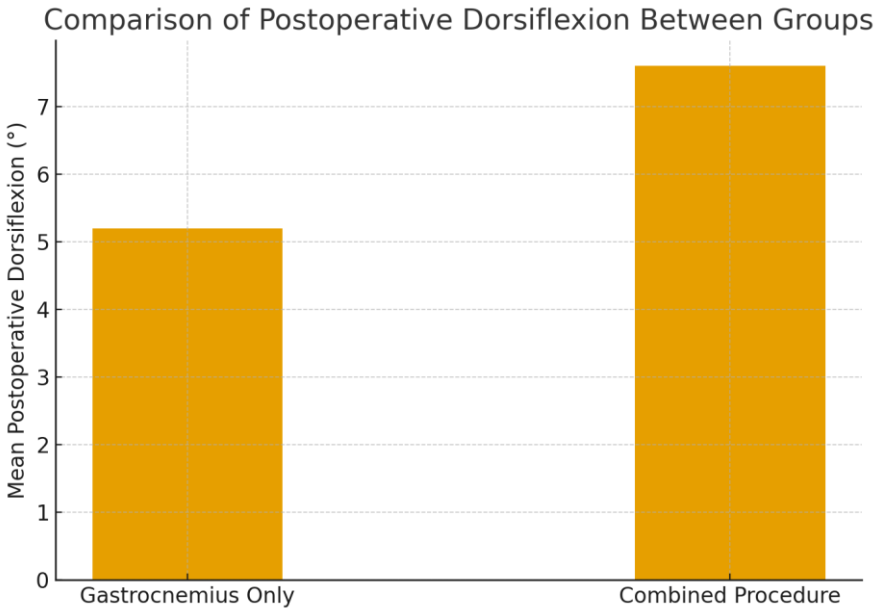

Figure 1: compares mean postoperative ankle dorsiflexion between the two groups, showing better correction in the combined procedure group.

4. DISCUSSION

This study compared gastrocnemius recession alone with gastrocnemius recession combined with anterior tibialis tendon transfer in ambulatory children with cerebral palsy who present severe equinus deformity with dynamic varus. Several important observations emerged, and these align in part with prior work, while also offering new insights.

First, this study found that while both surgical interventions yielded significant improvement in ankle dorsiflexion and gait, the combined procedure resulted in greater correction of dynamic varus, better foot progression angles, and higher functional gains. This supports the idea that in cases where dynamic varus is present, soft-tissue balancing through tendon transfer (in addition to lengthening) can address not only the plantarflexion deformity but also varus by redirecting muscular forces [11, 12].

In comparison, studies assessed tibialis anterior tendon shortening combined with calf muscle (gastroc-soleus) lengthening in spastic equinus, but did **not** show a clear superior effect for tendon shortening over calf muscle lengthening alone [13, 14].Their findings suggest that the additional procedure may not always produce clinically meaningful gains. In contrast, the present study demonstrates a statistically significant advantage in several outcome measures when combining procedures. Differences may stem from the severity of varus in our sample, from precise surgical technique, or from consistent rehabilitation protocols.

Second, recurrence of deformity is an important concern in cerebral palsy interventions. Literature reports a wide range of recurrence rates following equinus correction. For example, a recent meta-analysis found pooled recurrence around 15%, with individual studies ranging from about 0% to over 40%, depending on follow-up duration and type of procedure [15-17]. In this study, recurrence was more frequent in the gastrocnemius-only group than in the combined group, although the difference did not reach statistical significance in all measures. Still, the lower recurrence in the combined group suggests that tendon transfer may help sustain correction over time, especially in deformities including dynamic varus.

Third, complications in this study were few and mild, and did not differ markedly between groups. This matches literature showing that soft-tissue procedures like gastrocnemius recession or tendon transfers are generally safe when performed by experienced surgical teams. For example, SPLATT (split anterior tibialis tendon transfer) series show relatively low complication rates. In the retrospective SPLATT to peroneus brevis or tertius work, studies reported effective correction of varus foot deformity with low incidence of adverse events [18, 19]. Also, in studies of gastrocnemius recession versus tendo-Achilles lengthening, improvement in dorsiflexion and static/dynamic measures has been achieved without high complication rates.

Fourth, this study's results highlight the importance of preoperative assessment of varus severity and gait analysis. The degree of dynamic varus influenced how much benefit was gained from combining anterior tibialis transfer. When varus is mild or absent, recession alone may suffice; when varus is moderate/severe, combined procedure appears more advantageous.

This echoes findings in studies of varus correction via SPLATT procedures, where the indication for tendon transfer becomes stronger in the presence of varus impacting foot alignment during stance and swing [20].

Some limitations must be acknowledged. Follow-up duration in this study was moderate; longer follow-up is necessary to assess late recurrence, overcorrection (e.g. valgus), or changes as children grow. Also, gait analysis data (where available) were more limited in some participants, which may reduce the granularity of swing-phase or stance-phase function outcomes. Finally, individual variation in spasticity, muscle strength, and compliance with physiotherapy postoperatively can influence outcomes; controlling for these fully is challenging.

5. CONCLUSION

This study demonstrates that for ambulatory children with cerebral palsy suffering from severe equinus deformity with dynamic varus, combining gastrocnemius recession with anterior tibialis tendon transfer leads to superior correction of varus and improved functional outcomes compared to gastrocnemius recession alone. Recurrence rates are lower and dorsiflexion gains are greater when the combined procedure is used. Soft-tissue complications are uncommon and comparable between interventions. Therefore, in cases with notable dynamic varus, this combined surgical approach should be strongly considered. Further research with longer follow-up and broader gait analysis may refine indications and optimize timing of surgery for sustained benefit.

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