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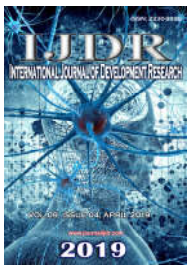

RESEARCH ARTICLE OPEN ACCESS

SURGICAL VARIETIES IN THE MANAGEMENT OF TIPTOEING CEREBRAL PALSIED SPASTIC CHILDREN

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ABSTRACT

Sixteen children with fixed equinus deformity of the ankle due to spastic cerebral palsy were evaluated and surgically treated in a prospective study held at the orthopaedic department of Rafae General Hospital during the period from March 2015 to June 2017. The aim of the study were to cite through proper clinical assessment the specific deformities that contribute to tiptoe standing or walking in these children and to choose the appropriate surgical procedures , in order to improve their functional outcome .There were 9 boys and 7 girls with their ages up to 10 years. The pattern of spastic cerebral palsy was hemiplegia in 3, diplegia in 9 and quadriplegia in 4 patients with a total number of 29 involved lower limbs. Primary equinus deformity was reported in 5 feet and secondary equinus deformity in 24 feet .A total of 68 surgical procedures was performed aiming at correcting the deformities an d improving the gait in these children. To correct fixed equinus deformity at ankle 3 types of surgical procedures were utilized in 29 feet. These procedures were sliding percutaneous lengthening of Achilles tendon in 8 feet, open z-plasty of Achilles tendon in5 feet and gastrocnemius recession in 16 feet. The functional outcome in term of deformity correction was 100% good results in gastrocnemius recession .compared to 62.5% and 40% good results in percutaneous lengthening and Z-plasty of Achilles tendon respectively. Under correction with recurrent or persistence of fixed equinus deformity was not reported in gastrocnemius recession cases but it was 25% after sliding percutaneous lengthening and 20 % after Z- plasty of Achilles tendon. Overcorrection with resultant calcaneus deformity was not reported after gastrocnemius recession but had occurred in 12.5% of sliding percutaneous lengthening and in 40% of Z-plasty cases. Satisfactory results in term of gait improvement were obtained in all children of the secondary equinus group. Those children who were only capable of standing with support before surgery were in 88.9% of cases converted into walkers (66.7% independent walkers and 22.2% walkers with aid). All children who before surgery were capable of waking with aids had become independent walkers (100% conversion rate).The study concluded that a properly selected child with spastic cerebral palsy will benefit a lot from surgical interference.

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INTRODUCTION

Cerebral palsy (CP) consists of a heterogeneous group of no progressive clinical syndromes that are characterized by motor and postural dysfunction. These conditions, are due to abnormalities of the developing brain resulting from a variety of causes. Although the disorder itself is not progressive, the appearance of neuropathology lesions and their clinical expression may change over time as the brain matures

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Clinical Features

In affected patients, a voluntary movement that should be complex, coordinated, and varied is instead uncoordinated, stereotypic, and limited. Simple actions that are performed unconsciously by unaffected individuals require marked effort and concentration and often fail in patients with CP. In severely affected individuals, an attempted voluntary movement may evoke a primitive reflex, co-contraction of agonist and antagonist muscles, and mass movements (1). For example, attempts at flexion may involve all segments of a limb, and extension of all the fingers may accompany

extension of the wrist. Discrete movements, such as that of an individual finger, may be impossible.

Classification of CP syndromes:

l-Spastic syndromes (spastic hypertonia):
(A).Spastic diplegia: (B).Spastic hemiplegia:
(C). Spastic quadriplegia
(2).Dyskinetic syndromes:
(3).Ataxic syndromes:
(4).Atonic syndromes:'
orthopaedic surgeries for cp children
A-Muscle-tendon surgery
B-Split tendon transfers
C-Osteotomies
D-Arthrodesis

PATIENTS AND METHODS

During the period from March 2015 to June 2017 a group of sixteen children with spastic cerebral palsy were evaluated and treated in a prospective study at the orthopedic department in Al-Rafae General Hospital. All had standing or walking on the tips of their toes (tip toeing). Only children up to age of 10 years were included. Age ranged from 3 - 10 years. There were 9 boys and 7 girls. There were 3 hemiplegics (1 left side and 2 right side involvement), 9 diplegics and 4 quadriplegics. 29 lower limbs in these sixteen patients were operated upon. A total of 70 surgical procedures were pet formed. All surgeries were performed under general anesthesia. 8 patients had undergone multisession surgeries while in the remaining 8 patients single session, multilevel surgery had been performed. All patients 'were clinically evaluated by:

- Detailed history about prenatal, perinatal and postnatal causes of brain insult.
- Detailed physical examination:with special emphasis on the presence of spasticity. contractures and muscle power assessment.
- Gait analysis using the observation method.

In each patient a differentiation was made between primary and secondary ankle equinus , as a cause of tiptoeing. This was done by forma examination of ankle, knee arid hip joints in each limb. In primary deformity .the ankle has equines deformity but the knee and hip are normal, while in the secondary deformity the equines deformity of the ankle is associated with contractures and deformities in the knee or hip joints or both.

The operations, indications and techniques

1-Fixed equinus deformity
A-Elongation of Achilles tendon

Elongation of tendo Achilles (ETA) was indicated when there was fixed equinus deformity of the ankle which prevented passive dorsiflexion of the foot to right angle or beyond when the test was performed both in flexion and extension of the knee joint .This was recorded in 13 feet. In each of these feet ETA was performed in the following ways:
A-1-Z-plasty:

Performed in 5 feet through a posteromedial incision.
A-2-Sliding method:

Fractional elongation of the Achilles tendon (Hoke method) was performed in 8 feet. Three opposing cuts in the tendon, each halfway along the tendon was performed, Sliding through an open posteromedial incision was performed in 4 feet. In the remaining 4 feet percutaneous sliding through 3 small separated incisions was performed,

B-Gastrocnemius slide recession (strayer): This is indicated when there is positive Silverskoild test. Fixed equines deformity of the ankle which prevented passive dorsiflexion of the foot to right angle when the knee is extended but the ability to dorsiflexion it beyond right angle when the knee is flexed. This was reported in 16 feet.Through posterior incision in the back of the leg at junction of middle and lower thirds, the gastrocnemius aponeurosisis exposed and is isolated from the underlying soleus muscle. A transverse incision of the Aponeurosis was performed in a lateral to medial fashion to ensure complete release.

A- Post operative care: Immobilization by above knee complete plaster of Paris cast for 3 weeks was used following any of the above surgical procedure of Achilles tendon. Immediate weight bearing was allowed if this was the only surgery and if the patient condition allowed .Following removal of cast physiotherapy and removable orthoses were utilized for additional 3 months.

RESULTS

Sixteen patients with spastic cerebral palsy were treated surgically. The distribution of patients according to age group is shown in Table (1) Ten patients out of 16 were in the age (4-5 years) representing 62.6% from all patients.

Table l. Age distribution in patients

Age in years	No. Of patients	Percent
3	2	12.5%
4	5	31.3%
5	5	31.3%
6	1	6.2%
8	1	6.2%
10	2	12.5%
TOTAL	16	100.0%

In the 16 patients with 29 lower limbs operated upon in this study , the pattern of foot equinus deformity was primary in 4 patients (3 hemiplegics and 1 diplegic) with 5 lower limbs. In the remaining 12 patients (24 lower limbs), in addition to ankle equinus, there is another proximal associated deformities in the knee or hip or both indicating secondary equinus pattern as in table 2. Surgical procedures to correct fixed equinus deformity of the ankle was performed in all patients (16 patients with 29 feet) whether the condition was primary or secondary equinus. From these 29 surgical procedures, gastrocnemius recession was performed in 16 feet (55.2%) and surgery on Achilles tendon was performed in the remaining 13 feet (44.8%) as in Table 3. Additional 39 surgical procedures were performed to correct associated knee flexion contractures (22 operations), hip adduction (16 operations) and hip flexion deformity (1 operation),as in Table 4. To complete the whole operative treatment course for any particular patient single surgical procedure alone (i.e. one level surgery) was needed in 3 patients (hemiplegics),2 surgical procedures in 1 patient, 4 surgical procedures (4 levels) in 5 patients, 6 procedures in 6 patients and 7 procedures in 1 patient as in Table 5.

Table 2. Distribution of lower limb deformities in 29 lower limb

Type of deformity	Isolated equinus		Ankle equinus+ knee flexion		Ankle equinus+ knee flexion+ hip adduction		Ankle equinus +knee flexion+ hip adduction+ hip flexion		TOTAL	
	limbs	%	limbs	%	limbs	%	limbs	%	limbs	%
Primary equinus deformity	5	17.2	0	0	0	0	0	0	5	17.2
Secondary equinus deformity	0	0	8	27.6	15	51.7	1	3.5	24	82.8
Total	5	17.2	8	27.6	15	51.7	1	3.5	29	100

Table 3. Operation to correct fixed equinus deformity in 16 patients (29 lower limbs)

Operation		Hemiplegics No.of feet	Diglegics No.of feet	Quadriplegics No.of feet	Total	
					No	%
ETA	Z-plasty	1	4	0	5	17.2
	Sliding method	2	4	2	8	27.6
Gastrocnemius recession		0	10	6	16	55.2
Total		3	18	8	29	100

Table 4. Surgical procedures for knee and hip deformities

Surgical procedures	Hemiplegics	Diplegics	Quadriplegics	Total
Hamstring release	0	16	6	22
Adductor tenotomy	0	12	4	16
Iliopsoas recession	0	1	0	1
Total	0	29	10	39

Table 5. Sum of surgical procedures per patients

No. of procedures	Hemiplegics	Diplegics	Quadriplegics	Total	
				No. of patients	No .of procedures
1	3	0	0	3	3
2	0	1	0	1	2
4	0	2	3	5	20
6	0	5	1	6	36
7	0	1	0	1	7
Total	3	9	4	16	68

Table 6. Distribution of single and multiple session surgery in 16 patients and in 70 surgical procedures

Surgery	No. of patient	Total of procedures	%
Multisession	8	39	50
Single session	8	29	50
Total	16	68	100.0

Table 7. Outcome of surgery in relation to deformity correction

Type of spastic CP	Good%		Equinus%		Calcaneus%		Total%	
	No	%	No	%	No	%	No	%
Hemiplegia	3	100	0	00.00	0	00.0	3	100
Diplegia	15	83.4	1	5.5	2	11.1	18	100
Quadriplegia	5	62.5	2	25	1	12.5	8	100
Total	23	79.4	3	10.3	3	10.3	29	100

In 8 patients (50%) surgical procedures were performed in stages with a minimum of 3 months interval between each session (multilevel staged surgery). At least one year was needed to complete all surgical procedures in these patients. In the remaining 8 patients (50%), all surgical procedure at different anatomical levels were performed in one session (single session multilevel) as shown in Table 6. Wound breakdown had occurs at site of adductor tenotomy in 4 operative sites (5.7 %) and was successfully treated by frequent wound dressing. Superficial wound infection which healed completely on with oral antibiotic treatment and wound care had occurred in 2 operative sites (2.5%). The functional outcome of surgical treatment in regard to deformity correction was graded good, when the fixed equinus deformity was completely corrected and patient can stand or walk independently.

Equinus refers to persistence or recurrent of fixed equinus deformity at ankle while calcaneus refer to occurrence of static or dynamic calcaneus deformity at ankle following over correction of the equinus. Good result were obtained in 23 feet representing (79.4%) of cases, equinus in 3 (10.3%), and calcaneus in 3 (10.3 %) as shown in Table 7.

The functional outcome of surgery in relation to specific type of surgical procedures showed that ,in gastrocnemius recession there is no recurrent of deformity in any patient (100% corrected) while in other procedures for lengthening the Achilles tendon the recurrence of deformity in z- plastywas found in 3 patients (60%)and in 3 patients (37.5) for sliding method, Table 8.

Table 8. Functional outcome of surgery in relation to type of surgical procedure

Surgical procedures	Good%		Equinus%		Calcaneus%		Total%	
	No	%	No	%	No	%	No	%
z-plasty	2	40	1	20	2	40	5	100
sliding	5	62.5	2	25.5	1	12.5	8	100
Gastrocnemius recession	16	100	0	00	0	00	16	100
Total	23	79.4	3	10.3	3	10.3	29	100

Table 9. The state of children before and after surgical interference relative to standing and walking

Child at presentation	Before surgery	After surgery					
		Still only standing		Walking with aid		Independent walking	
	no	no	%	no	%	no	%
Standing with aid	9	1	11.1	2	22.2	6	66.7
Walking with aid	4	0	00.0	0	00.0	4	100
Total	13	1	7.6	2	15.4	10	77.0

DISCUSSION

Many children with spastic cerebral palsy who presented with tiptoeing standing or walking will need and benefit from lower limb surgery. The goal of surgery to improve the efficacy of gait by decreasing the energy cost. This can be achieved by minimizing contracture and balancing spasticity. When anxious parents bring the child for assessment, they expected that surgery will revert the condition to normality but unfortunately the basic ability to walk is determined by the patient brain and will not be affected by orthopaedic procedure (2) No absolute rules exist regarding the best time for surgery .Factors such as maturation level of the CNS which occurs around the age of 4-6 years, the walking potential of the child and the rate of deformity development, play role in deciding time of surgical intervention (3). In this study (69%)of cases were operated upon in the age group 4-6 years (11 out of 16 patient).This age allows the surgeon to accurately assess the degree of muscle imbalance and to exclude other abnormalities such as athetosis or dystonia. Fixed equinus deformity of the ankle, whether in isolation (primary equinus) or in association with other deformities in proximal knee and/or hip (secondary equinus) is very common in spastic diplegic or quadriplegic cerebral palsy. This will present as tiptoe standing or walking. To surgically correct fixed ankle equines in the secondary type by lengthening of ankle flexors alone such as gastrocnemius recession or elongation of tendoachilles will not solve the problem. Leaving the contracted hamstrings will result in increased hip and knee flexion deformities resulting in crouch posture and gait. In this study, the majority of fixed equinus was of the secondary type constituting (82.8%) of cases. The main associated proximal deformity reported was knee flexion contracture due to hamstring spasticity that occurred in all such cases (100%). This was corrected by hamstring release as an essential part in the surgical treatment of these children. A lot of controversy exists about which technique is most appropriate to correct fixed equinus of the ankle per se whether by Achilles tendon lengthening or gastrocnemius recession procedures. This issue is still unknown and controversial (64).In the study, gastrocnemius recession was performed in 66.6% (16/24 of all secondary equinus deformity feet), while procedures to lengthen Achilles tendon by percutaneous method or by Z-plasty was used in the remaining (43.4%), (8/24). The short term results. In the study showed a (100%) equinus correction rate with no under or overcorrection in gastrocnemius recession treated feet. The results with sliding lengthening of the tendoachilles was (62.5%) good results, (25%) under correction with residual equinus and (12.5%) overcorrection with resultant calcaneus deformity while for Z-plasty, the results were only (40%) good, (20%) under correction and (40%) overcorrection. The study had found gastrocnemius recession more superior to heel cord lengthening procedures because it is simple and effective and is particularly indicated when long periods of immobilization of the foot and ankle are not desirable(5).Unlike Achilles tendon lengthening, gastrocnemius recession does not cause a weakening of triceps surae muscle and it improves static and dynamic function of the ankle(6) with decreased risk of over lengthening (7'8'9'10). With Achilles tendon lengthening, the risk of over lengthening leading to crouch gait can occur up to 50% of case (7'11'12'13'14'.) Lengthening by Z-plasty is more useful in older and neglected cases where the tendon is markedly contracted and short. the current study, the short term functional outcome in relation to deformity correction and improvement in the gait and walking ability was greatest in hemiplegic and diplegic children with a rate of (100%) and (83.4%) good results respectively The quadriplegics showed the lowest rate of improvement (62.5% good results).These results are in agreement with other studies which stated that diplegic and hemiplegic children improve more compared to spastic total body involvement (15). This may reflect the degree of severity of central nervous system involvement rather than the outcome of surgical procedures only. Most authors agree that functional prognosis can be predicted once the clinical picture is established since approximately (85%) of partially involved cerebral palsied children have the potential to become independent ambulators compared to only (15%) of severely involved (16). The majority of children in this study (75%), had required 4 to 7 surgical procedures at different anatomical levels to correct their contractures in order to reach the final goal of treatment i.e. gait improvement. Early in the study .staged surgery in multiple sessions was utilized. This was done in (50%) of patients of the secondary equinus group. During each session correction of deformities at a single anatomical level was performed (e.g. performing only bilateral gastrocnemius recession).

The duration of treatment in these children was one year or more to complete all surgical procedures. This approach was found to have a lot of problems such as poor family cooperation, long periods of hospitalization Joss of motivation, together with psychosocial complications for both the family and child. The shift to single session multilevel surgical approach was used in the remaining (50%) of children in the secondary equinus group. All surgery directed to hip, knee and

ankle such as hip adductor release, hamstring and gastrocnemius lengthening were completed in a single session. This multilevel single session surgical approach was proved to be very fruitful in term of convenience to family, reduction in time of hospitalization and in achieving better functional results in a short period of time if it is combined with intensive postoperative physiotherapy and properly used bracings. This trend of multilevel one session surgical treatment becomes the method of choice in treating spastic cerebral palsy throughout world (17,18,19) Multilevel surgery is not the universal solution for every diplegic or quadriplegic child. Some children need hamstring or gastrocnemius lengthening only. The treatment plan must be individualized for each child according to his or her needs.

Conclusions

- Gastrocnimus recession is the preferable procedure over Achilles tendon lengthening to correct fixed equinus deformity at the ankle in spastic CP .It gives good outcome in relation to deformity correction and gait improvement.
- Hamstring knee contractures was the most second cause of tiptoeing in spastic diplegics and quadriplegics CP and should be corrected simultaneously with ankle equinus deformity.
- Single stage multilevel soft tissue surgical procedures to correct fixed deformities in spastic diplegics and quadriplegics CP had a reasonable correction of deformity in a short period of time together with improvement in the final outcome . It is associated with minimal psychosocial impacts on the child and its family.
- Surgical procedures interference in spastic CP had a satisfactory function results with minimal complication and should be done routinely in these children.

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