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Session 1

Cerebral Palsy

EFFECTS OF SURGERY ON PELVIC RETRACTION DURING GAIT IN DIPLEGIC CEREBRAL PALSY

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SUMMARY

The effects of surgery on pelvic retraction during gait were examined in diplegic cerebral palsy patients. Gait data of 19 patients who demonstrated significant pre-operative pelvic retraction were studied retrospectively. Those who underwent a femoral derotation and/or a psoas recession showed the most significant improvement ($p < 0.01$) while those who did not undergo a femoral derotation or psoas recession did not show a significant change in pelvic retraction ($p = 0.34$). This confirms our previous finding that pelvic retraction is primarily related to internal rotation and flexion of the hip in diplegic cerebral palsy.

CONCLUSIONS

In diplegic cerebral palsy surgery about the hip joint leads to the most significant improvement in pelvic symmetry particularly a femoral derotation osteotomy.

INTRODUCTION

Pelvic retraction is a common feature of gait in cerebral palsy. Studies have shown that pelvic retraction improves following femoral derotation osteotomy in conjunction with soft-tissue surgery but also following soft-tissue surgery alone [1]. Our previous work suggested different causes for pelvic retraction among diplegic and hemiplegic subjects [2] and so the effects of surgery should be examined separately in these two groups. The purpose of this study was to examine the effects of surgery on pelvic retraction in diplegic cerebral palsy.

PATIENTS/MATERIALS AND METHODS

Excessive pelvic retraction during gait was defined as >6.85° based on a previous study of normal subjects (mean + 2S.D., $n = 59$, age range 5–32 years). One hundred and twenty-six patients with diplegic cerebral palsy who had undergone gait analysis using the CODA mpx30 system from 1998 to 2004 were reviewed. Patients who displayed excessive pelvic retraction, had undergone surgery, and had returned for a post-operative gait analysis were identified. This group was further subdivided based on the surgical procedures carried out. Pelvic rotation was compared in these groups pre and post surgery using a paired *t*-test.

RESULTS

Nineteen diplegic cerebral palsy patients were reviewed (10 female, 9 male). All subjects underwent surgery (mean number of procedures 2.2 ± 1.2, age at surgery 10.5 ± 3.2 years) and returned for a post-operative gait analysis (mean review time 19.5 ± 11.1 months). Comparison of pre- and post-surgical pelvic rotation is shown in the Table. Significance level was set at $p < 0.05$.

Surgery	*N*	Pre-operative mean (S.D.)	Post-operative mean (S.D.)	*p* value
All	19	−9.46 (2.58)	−3.07 (7.87)	<0.01
FDRO	7	−9.05 (2.28)	−2.16 (3.91)	<0.01
No FDRO	12	−9.7 (2.81)	−3.59 (9.60)	0.05
FDRO and/or psoas	12	−9.59 (2.16)	−2.00 (5.57)	<0.01
No FDRO, no psoas	7	−9.24 (3.36)	−4.88 (11.07)	0.34

FDRO: femoral derotation osteotomy, Psoas: psoas recession.

DISCUSSION

The effect of surgery on pelvic retraction in diplegic cerebral palsy was examined. Despite small numbers this study shows that hip derotation and psoas recession lead to the most significant improvement in pelvic symmetry. This adds weight to our previous findings that retraction was most associated with hip flexion and internal rotation in diplegic subjects [2]. Further study is needed to examine the effects of surgery in hemiplegic patients.

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CAN MULTILEVEL BTX-A TREATMENT PREDICT THE EFFECT OF SDR ON GAIT IN CHILDREN WITH SPASTIC DIPLEGIA?

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SUMMARY

The effect of multilevel botulinum toxin A (BTX-A) treatment at a young age was compared to the effect of selective dorsal rhizotomy (SDR) at a later age, on gait in children with diplegia.

CONCLUSIONS

Multilevel BTX-A and SDR both significantly improve the gait pattern in children with diplegia. Because of differences between pre-treatment conditions, the effect of BTX-A was found to be significantly higher for ankle parameters compared to the effect of SDR. However, SDR more pronouncedly improved gait patterns at the more proximal levels (hip and pelvis).

INTRODUCTION

Both, multilevel BTX-A injections and SDR, are known as successful tone reduction treatments, improving gait in children with CP. Because SDR is an irreversible treatment, carefully patient selection is crucial. The purpose of the study was to evaluate whether the effect of SDR on gait could be simulated by multilevel BTX-A treatment at a younger age.

PATIENTS/MATERIALS AND METHODS

The group consisted of 11 children with spastic diplegia, with periventricular leucomalacia, ambulant, with good strength and selectivity, and without previous orthopaedic surgery. All children received multilevel BTX-A injections, combined with casting, appropriate physiotherapy and orthotic management, at a mean age of 5.6 years and received SDR at a mean age of 7.1 years. Both interventions were planned by the same multidisciplinary team. Each child underwent a comprehensive evaluation including clinical examination and 3D gait analysis with joint kinematics, kinetics and surface EMG of eight lower limb muscles, in the month before and 2 months post BTX-A, and pre and 10 months post SDR. Thirty-three gait parameters were assessed blind by the same kinesiologist at the different evaluation times. Median and interquartile range was calculated for each parameter at each evaluation time. Wilcoxon signed rank test was used: (1) to evaluate the differences between pre and post BTX-A and between pre and post SDR and (2) to compare the effect of the BTX-A treatment with the effect of SDR on gait (with a critical p value of 0.01).

RESULTS AND DISCUSSION

Both treatments were found to significantly improve the gait pattern of children with dipegia. The most pronounced effects after BTX-A treatments were seen at the level of the ankle. The effects of SDR were more equally distributed over the ankle, knee, hip and pelvis. Although the ankle kinematics significantly improved after both interventions ($p < 0.01$), the correction of the ankle position at initial contact and terminal stance was significantly more pronounced after BTX-A compared to SDR. This higher correction can be related to differences in the pre-treatment condition. Due to previous BTX-A treatment combined with casts, the ankle pathology was significantly less pronounced before SDR compared to the pre-BTX-A condition. On the other hand, BTX-A slightly over-corrected the ankle dorsiflexion at loading response, whereas SDR normalized the ankle angle at loading response. BTX-A did not significantly influence the knee angle at initial contact. Because SDR nicely improved knee angle at initial contact the effect of SDR was found to be significantly higher than the effect of BTX-A. Both, BTX-A and SDR, result in an improved knee extension in stance, but the effect of SDR was found to be significantly higher for SDR. After SDR, hip rotation at initial contact and pelvic stability in the sagittal plane significantly improved. Similar tendencies

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could be found after BTX-A, but these changes did not reach the defined level of significance. In order to identify good and excellent responders to SDR by evaluating the effect of multilevel BTX-A treatments at a younger age, further investigation should be carried out on a large patient cohort.

ASSESSMENT OF MULTI-LEVEL SURGERY RESULTS AT ONE AND TWO YEARS FOLLOW-UP USING THE GILLETTE GAIT INDEX

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SUMMARY

We used the Gillette Gait Index (GGI) to assess the results of multi-level surgery in diplegic cerebral palsy (CP). At one year post-surgery all patients had more than 10% improvement in their GGI. At two years follow-up the improvement, on average, was maintained.

CONCLUSIONS

Our results at one year compare favourably to published series and, on average, improvement is maintained at two years; 23/24 patients followed up to two years maintained an improvement of 10% or more compared to pre-op.

INTRODUCTION

The Gillette Gait Index was introduced as a tool to quantify the amount by which a subject's gait deviates from the average able bodied individual [1]. The GGI has been used before to evaluate results of surgical interventions [2]. We aimed at assessing our multi-level surgery results at one year post-op in order to compare them with published data. We took this further than the published literature by calculating the GGI at two years post-surgery to establish whether the results of multi-level surgery are maintained.

PATIENTS AND METHODS

Between 1997 and 2003 we performed bilateral multi-level surgery on 52 children with diplegic CP. Thirty-six patients (23 boys, 13 girls, average age 11.9 years, S.D. 2.8 years) fulfilled the inclusion criteria at one year post-op and 24 at two years. Thirty able-bodied children (13 boys, 17 girls, age 9.8 years) were used as controls. The GGI was calculated for three representative gait cycles from three separate trials for each leg following the methodology described by Schutte et al. [1]. GGI values were averaged between legs for each patient. Comparisons were made between pre-op and one and two years post-op data. A change of GGI > 10% was considered significant [2].

RESULTS

Table 1 shows the mean GGI values and standard deviations as well as the observed changes.

	Mean GGI	S.D.	No. improved >10% from pre-op	Change 1–2 years
Pre-op ($n = 36$)	344	170	N/A	
1 year post-op ($n = 36$)	171	116	36/36 (average 51% improvement)	
2 years post-op ($n = 24$)	174	97	23/24 (average 49% improvement)	Average 6% worse

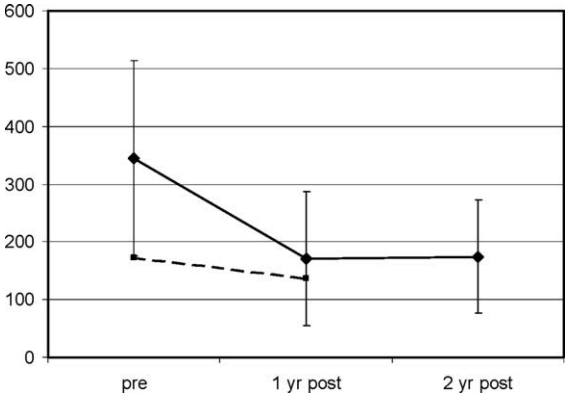

Fig. 1. Comparison of our GGI results at one year post-op with those previously published (dashed line). At two years post-op there is no significant change in the average GGI (seven improved, nine were unchanged and eight worse >10%).

DISCUSSION

We looked in detail at the data of patients excluded and although we could not calculate the GGI at one year, we confirmed that after two years the GGI of a sub-group of five excluded patients showed similar improvement. Our results compare favourably with those previously published. Our patients, however, were older and more severely affected than those from Gillette. This may indicate different selection criteria for surgery.

REFERENCES

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DO AFO'S IMPROVE THE GAIT EFFICIENCY IN CHILDREN WITH CP?

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SUMMARY

It is generally accepted that in children with cerebral palsy (CP) ankle foot orthoses (AFO) biomechanically and functionally improve the gait pattern. In our study, metabolic energy measurements were used to evaluate the energy efficiency of walking with AFO's.

CONCLUSIONS

Our results indicate that, although AFO's are improving the biomechanics and the functional parameters of walking in children with CP, the efficiency does not increase, probably due to compensations elsewhere.

INTRODUCTION

It is well recognized that deviations in gait pattern result in excessive energy requirements in children with CP [1]. They are often prescribed AFO's to optimize joint motion of the ankle during gait. By normalizing joint motion the energy efficiency of gait and thus the functional motor skills of the child should improve [2]. It is important to examine the effectiveness of AFO's not only by looking at parameters of mechanical movement through GA but also at metabolic energy use. Metabolic measurements include muscle action to prevent undesired movements, which cannot always be detected through GA. Furthermore, metabolic energy is measured during walking longer distances, whereas GA focuses on a limited number of gait cycles.

PATIENTS/MATERIALS AND METHODS

Nine children with CP aged between 6 and 10 years received a breath by breath oxygen consumption measurement (Cosmed K4b2) and a full 3D GA (Vicon) during walking barefoot and with individually tuned posterior leafsprings. Energy measurement was performed using a standardized protocol of 5 min sitting (base line), 3 min standing and 8 min walking on an 8 shaped walking track. The whole protocol was repeated after 1 h of rest. Children who started first with AFO's walked then barefoot and vice versa. The order of the test condition was randomly selected. The average and standard deviation of a steady state period of 3 min in the second half of walking was calculated in both conditions for heart rate, oxygen rate, oxygen cost and velocity. Wilcoxon signed rank test was used as a common heuristic to decide upon the statistical significance of the observed differences between the two walking conditions ($p < 0.05$).

Table 1
Metabolic gait efficiency in walking barefoot and with AFO's

Walking	Mean ± S.D.		p
	Barefoot	AFO	
VO2/kg (ml/(min kg))	17.351 ± 2.099	19.949 ± 2.883	0.027
HR (bpm)	126 ± 12.6	134 ± 12.9	0.023
Velocity (m/s)	1.182 ± 0.163	1.237 ± 0.194	0.129
O_2 cost (VO2/(kg m))	0.246 ± 0.022	0.271 ± 0.032	0.020

RESULTS

During walking all four energy parameters, apart from walking velocity, increased significantly, comparing AFO's to barefoot. GA parameters showed a clear improvement for the kinematics at the ankle (first and second rocker, foot clearance) and slight improvements at knee and hip, however with a decrease in power generation at push off.

DISCUSSION

In our study, there was no benefit in gait efficiency when the children were walking with their AFO's designed to optimize their walking pattern. With AFO's, velocity showed a trend to increase, but energy consumption increased too. We can conclude that in children with CP energy efficiency does not necessary benefit from the improving gait pattern with AFO's when walking at longer distances. There are probably muscle actions at upper body to prevent undesired movement that are not detected by GA. The decrease in power generation may be compensated more proximal, increasing the energy consumption further. Our results suggest that in wearing orthotics children are not only doing a mental but also a physical effort. More studies combining GA and metabolic measurements should be done for better understanding of the discrepancy between the biomechanically improved gait cycle and the reduced energy efficiency.

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THE RESULTS OF TWO STRENGTH TRAINING REGIMES ON GAIT AND FUNCTION IN CEREBRAL PALSY FOLLOWING MULTI-LEVEL SURGERY

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SUMMARY

This study was undertaken to establish the clinical effectiveness of an active versus a progressive resistance strength training regime during rehabilitation following multi-level surgery in children with cerebral palsy (CP).

CONCLUSION

Both training regimes resulted in significant improvements in muscle strength and motor function, while resistance training resulted in a greater change in hip flexor and knee extensor strength and additional improvements in gait kinematics and walking speed.