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Hip Migration after Selective Posterior Rhizotomy in Cerebral Palsy

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— **Abstract** —

Hip subluxation and dislocation are common orthopaedic problems in children with cerebral palsy. Selective posterior rhizotomy(SPR) is a neurologic procedure aimed in reducing spasticity. Several recent studies have indicated a decrease in spasticity and functional improvement after SPR, and also decrease the tendency toward hip subluxation in children with cerebral palsy. This is a retrospective study to examine whether SPR halts hip subluxation. Between May 1994 and July 1996, 22 children below age of 5 underwent SPR. Twenty children were spastic diplegic types and 2 were mixed type and quadriplegic type respectively. Approximately 50-80% of L2-S1 level dorsal roots was cut, and 13 children had 50% of both L1 roots cut. Migration percentage score (MP) was used to determine progression of hip subluxation during the follow up period (12 - 36 mos.; Average 15 mos.). Of the total 44 hips in 22 patients, 45.5% (20 hips) improved, 34% (15 hips) remained unchanged, and 20.5% (9 hips) were worsened after SPR. Radiographic stability was achieved in 79.5%. L1 root cut rate (L1 SPR) was 55.5% for improved hips, 67% for unchanged hips, and 50% for worsened hips. Two patients had undergone orthopaedic procedure for progressive hip migration. Most patients experienced postoperative hip stability after SPR, but 20.5% were worsened and 2 patients had orthopaedic procedure. Also it is unlikely that L1 root involvement prevents progression of hip migration.

Key Words : Cerebral palsy, Selective posterior rhizotomy, Hip migration

INTRODUCTION

Hip subluxation and dislocation are common orthopedic problems in children with spastic cerebral palsy, occurring in 3% to 59% of patients[2,4,8,10,12,21]. This hip deformity is not only a radiological abnormality, but also a cause of significant clinical problems. Hip subluxation in ambulatory patients

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affects posture and gait and causes pain; hip dislocation in nonambulatory patients causes fracture of the lower extremities, skin ulceration, and difficult perineal care[4,9,11,13,20,22,24,26]. The cause of this hip abnormality is multifactorial, but predominant spasticity in the hip flexors and adductors probably plays an important role in the development of abnormalities. Selective posterior rhizotomy(SPR) is a neurosurgical procedure aimed at reducing spasticity in children with spastic cerebral palsy. SPR reduces spasticity by decreasing the facilitory afferent input of the posterior nerve roots to the anterior horn cells involved in the spinal reflex arc[1,12,14,17-19,32]. Intraoperatively, rootlets that produce an abnormal muscular and electromyographic response to electrical stimulation are transected, resulting in a decrease in muscle tone and reactivity. Several recent studies have indicated a decrease in spasticity and functional improvements following SPR in children of cerebral palsy[5,8,10,15,17,25,28]. While reduction of spasticity following the dorsal rhizotomy may halt the progression of hip subluxation, it may also adversely affect hip stability and exacerbate hip subluxation. According to Park et al.[27], 93% of hips achieved radiological stable after SPR on his study of 134 patients. By decreasing spasticity, which is a major factor affecting the hip migration, SPR might be expected to decrease the incidence of hip subluxation in children with cerebral palsy. However, Greene et al.[7] have raised the possibility of progressive hip migration following SPR in their report on six patients, showing 7 hips of the 12 hips examined were found to exhibit progressive hip subluxation after SPR. It is thought to be caused by muscle imbalance after SPR leaving L1 root intact coupled with predisposing hip dysplasia[9]. Also, muscle hypotonia may causes rapid hip migration after SPR. Thus, we investigated whether SPR halts or exacerbate lateral hip migration, by retrospective study to examine those children with spastic cerebral palsy who underwent SPR procedure, and also, we compared the result of those who had L1 root transected to those not and to see if L1 root involvement affect the outcomes.

MATERIALS & METHODS

The study group was 22 children of below age 5, with spastic cerebral palsy who underwent selective posterior rhizotomy between May 1994 and July 1996 in Severance hospital. This study is a retrospective report based on their medical record and x-ray file. The age at surgery ranged from 2 to 5 years in 22 patients(Table 1). Eighteen patients were male and remaining 4 were female patients. Twenty patients were spastic diplegic type and remaining 2 were mixed type and quadriplegic type respectively(Table 2). Approximately, 50-80% of dorsal root fibers at the L2-S1 levels was cut. Also, 13 patients had both L1 roots cut 50%. Overall follow up periods were from 12 months to 36 months(Average 15 mos.). All patients took preoperative hip X-ray film. Follow-up hip X-ray films were taken regularly. Migration

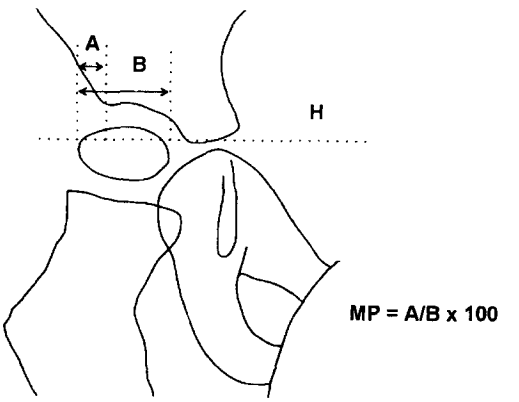

Fig. 1. Drawing displaying the source of values used to determine the migration percentage(MP). The MP is equal to A/B $\times$ 100. A = the portion of the femoral head extruded beyond the lateral edge of the acetabulum; B = the width of the femoral head; H = Hilgenreiner's line drawn through the acetabulum so as to touch the visible tips of the bilateral ilia on anteroposterior hip radiographs.

Table 1. Clinical data of 22 patients.

Age(years)	Mean	3.5
	Range	**2~5**
Sex	Male	18
	Female	4
Follow-up duration(months)	Mean	15
	Range	12~36

Table 2. Type of cerebral palsy

Type	No.
Spastic diplegia	20
Quadriplegia	1
Mixed type	1

Table 3. Overall MP score of 22 patients.

MP score	Pre-SPR	Post-SPR
Range	11-78(%)	10-68(%)
Mean	29(%)	27(%)

percentage score(MP) was used to determine progression of hip subluxation on plain hip X-ray film(Fig. 1).

RESULTS

The pre-op MP score ranged from 11% to 78% (Ave: 29%) and the post-op MP score ranged from 10% to 68%(Ave: 27%)(Table 3). Of the total 44 hips in 22 patients, 34%(15 hips) remained unchanged, 45.5%(20 hips) improved, and 20.5%(9 hips) were worsened after SPR(Table 4). Thus radiographic stability was achieved in 79.5%. Thirteen patients had L1 root transection of 50% bilaterally. L1 root cut rate (L1 SPR) was 55.5% for improved hips, 67% for unchanged hips, and 50% for worsened hips(Table 4). Two patients had undergone adductor tenotomy, iliopsoas tenotomy and Salter's osteotomy for a progressive hip subluxation after SPR.

CASE 1.

A 5-year-old male patient with cerebral palsy took an operation after SPR. He was born at IUP 32wks and had perinatal asphyxia. At the age of 2, he was diagnosed cerebral palsy with spastic diplegic type. He admitted to the Department of Rehabilitation Medicine for rehabilitation therapy. He was not able to walk at the age of 3 and his spasticity on low extremities got worsened. On plain hip x-ray film showed MP score 25% for right and 17% for left side(Table 5). To reduce spasticity, he admitted to the Department of Neurosurgery and took SPR at the age of 3. The level was from L1 to S1 bilaterally. After SPR, his spasticity was reduced tremendously, but still ambulation was not possible. Also, his hip muscle tone changed after SPR from fair to poor grade. After 12 months later, his follow-up x-ray showed MP score of 40% for right and 20% for left side, and 2 years later, x-ray film showed severe hip subluxation with acetabular dysplasia on right hip(MP score: 65%)(Fig. 2). Salter's innominate osteotomy and adductor tenotomy was performed

Table 4. The results of MP score after SPR

No. of Hips(%)	Improved	Unchanged	Worsened
Total 44 Hips	20(45.5)	15(34)	9(20.5)
L1 root involvement Total 26 Hips	11(55)	10(67)	5(55)

Table 5. Serial MP score of Case 1.

TIME	MP score	
	RIGHT	LEFT
Initial	25%	17%
12 months	40%	20%
2 years	65%	22%
Annual rate	20%/yr	2.5%/yr

Table 6. Serial MP score of Case 2.

TIME	MP score	
	Right	Left
Initial	60%	40%
13 months	80%	35%
Annual rate	18.5%	-13.8%/yr

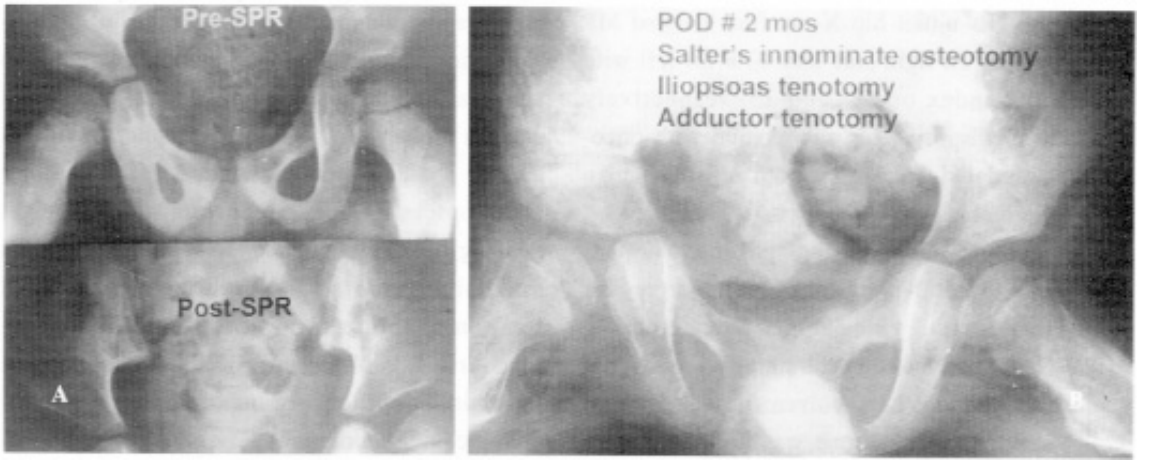

Fig. 2-A. Pre-SPR and post-SPR plain X-ray. Before SPR, the right hip was contained in the hip joint, but at 24 months after SPR, his right femoral head was displaced laterally.

B. Salter's innominate osteotomy, iliopsoas tenotomy, and adductor tenotomy was done due to progressive hip migration after SPR.

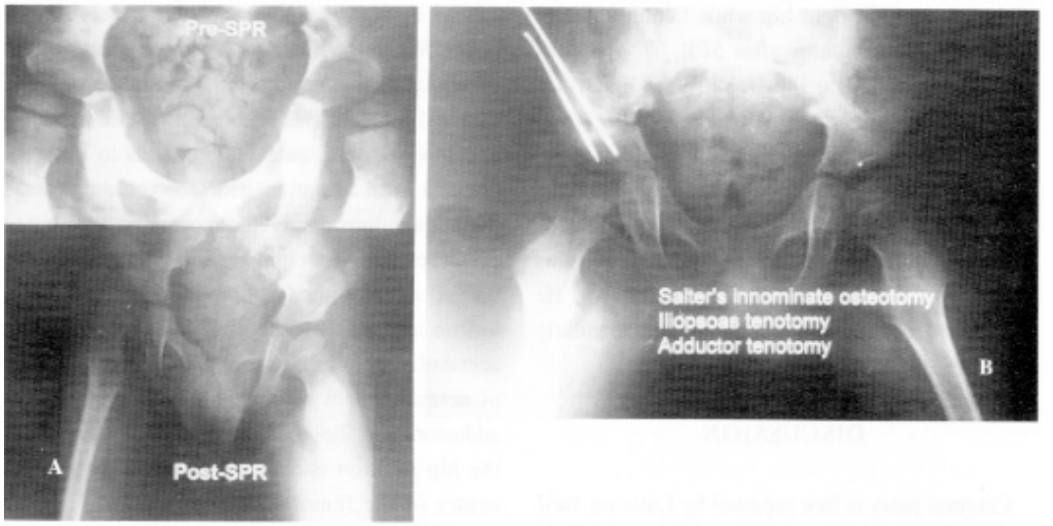

Fig. 3-A. The mild right hip subluxation was found before SPR, but the right hip was migrated progressively aggravated after SPR. Eventually at 13 months after SPR, the right hip was dislocated.

B. Salter's innominate osteotomy, iliopsoas tenotomy, and adductor tenotomy was done due to the dislocation of hip after SPR.

on right hip(Fig. 3). He was discharged with one and half hip spica cast. At the final follow-up(12 months after operation), his femoral head was contained in his hip joint stable.

CASE 2.

This 4-year-old male patient with cerebral palsy of spastic diplegic type admitted to the Orthopaedic Department for his right hip dislocation 1year after SPR(Fig. 3A). He was born at intrauterine period of 31 weeks due to premature rupture of membrane. He was diagnosed cerebral palsy at the age of 2. from the Department of Rehabilitation Medicine, he took a comprehensive

treatment. His initial hip X-ray film showed MP score of 60% on right side and 40% for left with acetabular index of 32° and 25° respectively showing predisposing hip subluxation with ongoing acetabular dysplasia on both hips(Table 6). Spasticity on his both low extremities hindered his movement and to reduce the spasticity, he was transferred to the Department of Neurosurgery for the SPR. He was 3 year old then. Nerve roots of L1 to S2 were transected bilaterally identifying them by EMG and L1 involvement was 50% on both sides. His muscle tone was decreased form fair to poor on both hip muscles, but spasticity was improved and came up to the level of standing with holding after continuous physical training. Then, accidentally, his physical trainer found out dislocation of his right hip while taking physical training just 11 months after SPR. Two months later, he admitted to the Department of Orthopaedeic Surgery and the MP score was 80% and 35%, showing improvement on the left side. Salter's innominated osteotomy and adductor tenotomy was performed on the right side for progressive hip subluxation(Fig. 3B). He was discharged with one and half hip spica cast. He also visits to our outpatient department regularly for follow-up.

DISCUSSION

Cerebral palsy is first reported by Little on 1862 which was called Little's disease then. On 1989, it was Williams who introduced the term of cerebral palsy. Cerebral palsy is difficult to define, as it is not a single disease entity but, rather, a convenient category denoting a wide spectrum of conditions having certain common characteristics. There are many disorders that may cause cerebral palsy. In patients with spastic cerebral palsy, subluxation or dislocation of the hip is a common orthpaedic deformity, with the reported incidence ranging from 3 to 60%. This hip deformity is not a radiographic abnormality, but a cause of significant clinical problems. The pathogenesis of hip subluxation and dislocation in spastic cerebral palsy is probably multifactorial. Implicated factors include spasticity and contracture in the adductor and iliopsoas muscles, absence of normal weight bearing, coxa valga, and pelvic obliquity and excessive femoral anteversion, i.e.,forward rotation of the femoral neck in relation to the transverse axis of the knee[2,23,29]. Of these factors, spasticity is particularly important since in children it causes shortening of muscles, muscles contracture, relative immobilization, and impaired longitudinal muscle growth[31]. Spasticity may be defined as a state of increase in tension of a muscle when it is passively lengthened, which is caused by an exaggeration of the muscle stretch reflex. When the iliopsoas muscle is shortened by spasticity and contracture, it brings the hip into external rotation and with this coupled with the excessive femoral anteversion, tends to keep the femoral head in the anterior acetabulum; hence, the acetabulum receives abnormally distributed pressures during weight bearing[2,23]. This impairs normal developmental remodeling of the acetabulum and causes acetabular dysplasia. This acetabular dysplasia further augmented by a lack of normal weight bearing. Moreover, when both adductors and iliopsoas are shortened, the axis of the hip rotation is transferred distally from the center of the femoral head to a point near the lesser trochanter[2,23]. All of the aforementioned abnormal process act together to slip the femoral head laterally and posteriorly, sometimes eventually dislocating the hip. The natural history of untreated hip subluxation in cerebral palsy is evidently that of progression. According to Vidal et al.[30] in children with spastic cerebral palsy who have a potential for independent walking, lateral hip migration increases 4% per year during first 5 years of life.

Selective posterior rhizotomy was first reported

by Foerster for the relief of spasticity in 1913, designed to reduce muscle tone by interrupting the afferent component of the stretch reflex arc[9,16]. It was Fasano et al.[6] in 1978, introduced modifications of Foerster's technique, which bases present technique. Peacock et al. subsequently modified his technique shortly after[9,16]. The selective posterior rhizotomy, despite the ongoing debate about techniques, complications and its safety, it has spread into worldwide practice during the last decade for reducing spasticity. Many authors are now believes that SPR is quite safe procedure for reducing spasticity in cerebral palsy, thus reducing hip migration[3,16,22,28]. But, there are reports of worsening hip migration after SPR[7,8]. In our result however, the SPR showed very effective in reducing spasticity and also tends to halt hip migration. But there are patients with worsened hip migration after SPR counting 20.5%. Compared to Vidal's study[30], we had cases of which took orthopedic surgery for progressive hip subluxation and their annual migration rates were 20% and 18.5% respectively; about 4 times greater than the natural course of hip migration with cerebral palsy. Green et al.[7] reported that coupled with progressive subluxation of the hips was always noted in patients who had preexistent hip dysplasia, as defined by Howard et al.[9]. Surgical techniques of SPR could explain rapid hip migration. Spasticity in the hip flexors, largely innervated by the L1 and L2 nerve roots, and leaving L1 roots intact with transection of L2-S2 would have an residual muscle imbalance and causes asymmetry of the hip flexors as compared with the hip extensors and abductors. In this study, 13 cases of L1 root involvement were evaluated, and compared to those without L1 transection, there were no significant differences on both groups. Also, one of two patients who had orthopaedic surgery after progressive hip subluxation had L1 root transection(case 2). This study did not prove Greene's theory, perhaps further study might be necessary that we had only 13 patients of L1 root involvement. However, the L1 root dissection is quiet troublesome procedure when compared to other roots; precise L1 root involvement necessitates opening of T12 level. As Greene et al.[7] mentioned, the risk of spinal deformity would be increased when extending above L2 level. But, nowadays this critical complication can be resolved by adopting laminotomy, and/or laminoplasty instead of laminectomy during SPR[31]. It might be the muscular imbalance that existed prior to SPR remained after SPR, and that causes the rapid hip subluxation. Muscular hypotonia would also contribute to the rapid hip subluxation, that all of our patients had difficulty even lifting their legs after SPR, and about average of 6 months of physical training was necessary for their functional improvement[16]. It is certain that SPR not only reduces spasticity but also tends to halt hip migration. But we must acknowledge that in those minor number of patients had experienced adverse effect. Therefore it is advisable that frequent clinical and radiographic examinations of the hips are needed after SPR, and early recognition of progressive subluxation would allow appropriate intervention before irreducible deformities develop, thus close cooperation between surgical subspecialties is a necessity for optimum patient care.

CONCLUSION

Most patients experienced postoperative hip stability which suggest that in children with spastic cerebral palsy, selective posterior rhizotomy halts lateral hip migration in majority of cases, but in this study, 20.5% of hips had worsened MP score and two of them had undergone orthopaedic operation for progressive hip migration. Also, it is unlikely that L1 root involvement prevents progression of hip migration. Therefore, continued follow-up is necessary for those cerebral palsy children after SPR.

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= 국문초록 =

5세 이하 뇌성마비 환자에서 선택적 척수신경 후근 절제술 후 고관절의 변화

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고관절의 아탈구와 탈구는 경직성 뇌성마뇌 환자에서 흔히 관찰되는 정형외과적 문제이다. 이러한 뇌성마비 환자에서 흔히 관찰되는 고관절의 불안정성은 복합적 요인에 의하여 발생한다고 하지만 대퇴 굴곡근과 내전근의 경직이 주된 원인으로 알려져 있다. 선택적 척수신경 후근 절제술(SPR)은 뇌성마비 환자들의 근육 경직을 감소시키기 위해 개발되었으며, 최근 여러 보고들은 SPR이 경직의 감소와 기능적 향상뿐 아니라 고관절이 아탈구되려는 경향을 감소시킨다고 하였다. 그러나 몇몇 저자들은 SPR후 고관절의 불안정성이 악화되었다고 보고하고 있다. 따라서 저자들은 SPR이 고관절의 불안정성에 어떠한 영향을 주는지 알아보기 위하여 1994년 5월부터 1996년 7월까지 본원에 입원하여 SPR을 시술 받았던 5세 이하의 뇌성마비 환자22명을 대상으로 고관절의 변화를 조사하였다. 20명이 경지성 양측마비였으며, 1명은 경직성 사지마비 그리고 1명은 혼합형이었다. 제2요추 신경에서 제1 천추 신경까지 약 50-80%가 절제되었으며, 13명의 환자에서 제1 요추신경의 50%가 절제되었다. 고관절의 이동비율(migration percentage: MP score)이 고관절의 아탈구의 정도를 평가하기 위하여 사용되었다. 전체 22명의 환자 44 고관절에서 45.5%가 SPR후 고관절의 불안정성이 호전되었으며, 34%에서 변화가 없었으며, 20.5%에서 악화되어 79.5%에서 고관절의 안정성을 얻을 수 있었다. 제1요추 신경을 절제한 비율은 안정성이 호전된 고관절군의 55.5%, 변화가 없던 고관절군의 67%, 악화된 고관절군의 50%로 각 군간에 유의한 차이를 관찰할 수 없어, 제1요추 신경의 절제가 SPR후 고관절의 안정성을 향상시킨다고 할 수 없을 것으로 사료된다. 주목할 만한 점은 SPR후 고관절의 불안정성이 악화된 고관절중 2예에서 뇌성마미에 의한 고관절의 아탈구의 진행보다 현저히 빠르게 고관절의 아탈구가 진행됨을 발견할 수 있었으며 이들은 고관절에 대한 정형외과적 수술을 받았다. 따라서 SPR후 대부분의 경우 고관절의 불안정성이 호전되거나 변화가 없으나 20.5%에서 악화됨을 관찰할 수 있었으며, 악화되는 경우 그 진행이 매우 빠름이 관찰되어 지속적이며 세심한 정형외과적 추시 관찰을 요함을 알 수 있었다. 또한 제1요추 신경의 절제 여부가 고관절의 안정성 변화에 크게 영향을 주지 못함을 알 수 있었다.