The Effect of Obturator Nerve Block on Hip Lateralization in Low Functioning Children with Spastic Cerebral Palsy

Eun Sook Park, Dong-Wook Rha, Won Chul Lee, and Eun Geol Sim

Department and Research Institute of Rehabilitation Medicine, Yonsei University College of Medicine, Seoul, Korea.

Purpose: Hip adductor spasticity has a great impact on developing hip displacement in children with cerebral palsy (CP). Obturator nerve (ON) block is less invasive intervention than soft tissue surgery for reduction of hip adductor spasticity. The aim of this study is to investigate the effect of ON block on hip lateralization in low functioning children with spastic CP. Materials and Methods: The study was performed by retrospective investigation of the clinical and radiographic follow-up data of low functioning children [gross motor function classification system (GMF-CS) level III to V] with spastic cerebral palsy whose hip was subluxated. Migration percentage (MP) was measured on hip radiographs and its annual change was calculated. In intervention group, ON block was done with 50% ethyl alcohol under the guidance of electrical stimulation. Results: The data of 49 legs of 25 children for intervention group and the data of 41 legs of 23 children for nonintervention group were collected. In intervention group, the MP were significantly reduced at 1st follow-up and the MPs at 2nd and last follow-up did not show significant differences from initial MP. Whereas in nonintervention group, the MPs at 1st, 2nd and last follow-up were all significantly increased compared to initial MPs. Conclusion: ON block with ethyl alcohol is useful as an early effective procedure against progressive hip displacement in these children with spastic CP.

Key Words: Cerebral palsy, hip dislocation, nerve block, obturator nerve

INTRODUCTION

Cerebral palsy (CP) is the most common neurologic disorder that causes chronic disability in children. Spastic CP is the most common type of CP, and frequently leads to the development of progressive contractures and bony deformities. Moreover, hip displacement is one of the most common problems in the lower limbs after equinus foot. The incidence of hip dislocation is related to the severity of motor involvement. Hip dislocation is seen in up to 60% of children with total body involvement, whereas it goes down to 7% in ambulatory children with CP. A population study found that 54% of children who were not able to walk independently had unilateral or bilateral hip subluxation. If left untreated, hip subluxation can progress to dislocation, leading to serious problems such as pain, gait disturbances, difficulty sitting, and problems with perineal hygiene.
A hip surveillance program is recommended for early identification of hip displacement and early intervention to reduce the need for invasive reconstructive and salvage surgery. Radiologic measurements are commonly used for monitoring hip displacement. Reimer’s migration percentage (MP) is a valid and reliable measure of lateral hip displacement and the most commonly used radiologic parameter. Because spasticity of the hip adductor has the greatest impact on hip displacement in children with CP, early surgical adductor release has been largely used for alleviating progressive hip subluxation in children with CP. Recently, botulinum toxin type-A (BoNT-A) injection into hip adductor muscles has been tested for alleviating progressive hip displacement and has shown some beneficial effects in alleviating hip lateralization along with reducing hip adductor spasticity. In addition, children with low gross motor function, as determined by the gross motor function classification system (GMFCS; levels III to V), have poorer results in alleviating progressive hip dislocation after BoNT-A injection compared to children with high function at GMFCS levels I and II. The obturator nerve (ON) block is also considered an effective intervention for reducing hip adductor spasticity. Compared to BoNT-A, the ON block is less expensive. However, the effect of ON block on hip lateralization has not been investigated in children with CP. Therefore, the aim of this study was to investigate the effect of an ON block on hip lateralization in children with spastic CP with low function at GMFCS levels III to V.

MATERIALS AND METHODS

Patients
Medical records of children with CP who had radiographic hip surveillance between May 2006 and December 2008 were retrospectively reviewed. Among those cases, children who met the following inclusion criteria were selected: 1) children with bilateral spastic CP whose functions were at levels III to V based on the GMFCS, 2) children whose first hip radiographs were taken younger than 6 years of age, 3) children in whom radiographs of the hips were taken at least three times with intervals of more than 6 months, 4) children with hip MP between 20% and 60%, and 5) children with hip adductor spasticity ≥2 on the Modified Ashworth Scale. Children were excluded if they had previous orthopedic surgery or any chemoneurolysis within 6 months before the first hip radiographs. Among children who met the above criteria during the same time period, children who received an ON block were recruited as the intervention group and children who had not received any chemoneurolytic intervention (ON block or BoNT-A injection into hip adductor muscles), due to various reasons such as parental disagreement or burden of general anesthesia, were recruited as the nonintervention group. Hip orthoses were not applied to children of either group. Since the outcomes following soft tissue surgery for spastic hip subluxation are poor in cases with an initial MP of more than 60%, and soft tissue surgery is seldom indicated if MP is equal to or more than 60% due to the high failure rate of the surgical procedure, an ON block was performed only if MP was less than 60%.

Methods
Radiographs were obtained in a standard position. MP was measured by calculating the percentage of the femoral head that lies outside the lateral border of the acetabulum, which was defined by bony landmarks on pelvis anteroposterior radiographs. Because the duration between initial radiographs and follow-up radiographs was not the same among the children, the annual changes in MP (percentage/year) were calculated, with the interval changes in MP divided by duration (years). ON blocks were performed using the inguinal approach described by Choquet, et al. under general anesthesia. Choquet, et al. reported that the inguinal approach can block both anterior and posterior branches of the ON easier and more successfully with a lower risk of complications compared to the pubic approach. Ethyl alcohol (50%) was injected to block both the anterior and posterior branches of the ON bilaterally. Overall, 1 to 3 mL of ethyl alcohol was used to block each side of the ON according to the patient’s body weight and the spasticity of the hip adductors.

In the intervention group, hip adductor spasticity was assessed with the Modified Ashworth and Modified Tardieu Scales that measure the angle of muscle catch on the fastest movement (R1) and the passive range of motion (R2), before injection as well as 3 and 6 months after injection.

This study was conducted with the approval of our Institutional Review Board (4-2008-0605).

Statistics
Between the intervention and nonintervention groups, the numerical parameters were compared using independent t-tests, and nominal data were compared using chi-square.
A linear mixed-effect model with repeated measures was used to evaluate group differences in repeated MP measurements on the following factors: treatment, time, and treatment by time interaction with compound symmetry covariance structure. Two-sided $p$-values <0.05 were considered statistically significant. All data were analyzed using PASW for Windows (SPSS Inc., Chicago, IL, USA).

### RESULTS

A total of 49 legs from 25 children and 41 legs from 23 children were enrolled as the intervention and the nonintervention groups, respectively. We did not find any significant differences in the distribution of GMFCS, initial age of hip radiograph, or the follow-up period between the groups ($p>0.05$). The mean duration between the initial exams and the first follow-up exams were 7.23 months and 7.60 months in the intervention and nonintervention groups, respectively, and the mean duration between the initial exams and the final follow-up exams were 18.46 months in the intervention group and 20.10 months in the nonintervention group. The duration between the initial exam and each follow-up MP measurements were not significantly different between the intervention and nonintervention groups ($p>0.05$) (Table 1).

Initial MPs were not different between the intervention and nonintervention groups. In the intervention group, the mean MP at the first follow-up exam was less than the initial mean MP, and mean MPs at the second and final exams showed no difference from the initial MP after ON block. In the nonintervention group, mean MPs at all follow-up exams were greater than the initial mean MPs ($p<0.05$) (Table 2).

In this study, negative values for annual MP changes indicated improvement in hip displacement, and positive values indicated progressive hip displacement. The annual MP showed a statistically significant difference between the intervention and nonintervention group by linear mixed model ($p=0.002$). The annual MP during the first and second follow-up exams in intervention group showed interval improvement in hip displacement whereas the annual MP showed interval aggravation of hip displacement in nonintervention group (Table 3).

In the intervention group, the spasticity of the hip adductor muscles, as measured with the Modified Ashworth and Modified Tardieu Scales, was significantly reduced following ON block, and it lasted at least 6 months (Table 4).

### DISCUSSION

In terms of hip displacement, we found significant improvement in hip lateralization after ON block at the first follow-up exam. Despite our patient’s poor walking ability, the significant reduction in hip displacement following ON block suggested that an ON block may be an effective therapeutic intervention for alleviating hip displacement on a short-term basis. In addition, the significant differences in the annual changes in MPs at the second follow-up exam between the two groups seems to be caused by the carry-over effects of the initial reduction of hip displacement in the intervention group.
This was a retrospective study. As a result, some differences may exist between the two groups in various areas such as economic background, the patient’s general health status, existing family problems, frequency of other treatments, and the parents’ abilities/attitudes about taking care of their child, which may have influenced the outcomes. A further prospective randomized controlled study is needed to avoid this limitation of our study.

In conclusion, compared to initial MPs, the mean MPs at the first follow-up exam was significantly reduced in the intervention group, whereas the MP was significantly increased in the nonintervention group. In addition, the annual changes in MP were lower until the second follow-up exam in the intervention group compared to the nonintervention group. Despite the low functional level of our patients, a favorable effect of ON block with ethyl alcohol for alleviating progressive hip displacement suggests that it is useful as an early intervention for alleviating further hip displacement. The ON block is a helpful alternative intervention, especially when the cost of intervention is a concern or when the total dose of BoNT-A exceeds the maximum dose recommended for multilevel injections.

### Table 3. Comparison of MP Changes between the Intervention and Nonintervention Groups

| MP                        | Intervention group (n=49) | Nonintervention group (n=41) |
|---------------------------|--------------------------|------------------------------|
| Change (%)                | 1.59±9.45                | 3.20±9.32                    |
| 1st follow-up annual change (%/yr) | -12.41±30.93             | 4.23±12.31                   |
| 2nd follow-up annual change (%/yr) | -1.22±7.26               | 2.33±7.43                    |
| Last follow-up annual change (%/yr) | 1.09±7.63                | 2.35±6.85                    |

MP, migration percentage. Values are means±SD. A positive number in the annual change indicates worsening, and a negative number indicates improvement in MP. 1st follow-up annual change=(1st follow-up MP-initial MP)/period of 1st follow-up since initial MP measurement. 2nd follow-up annual change=(2nd follow-up MP-initial MP)/period of 2nd follow-up since initial MP measurement. Last follow-up annual change=(last follow-up MP-initial MP)/period of last follow-up since initial MP measurement.

### Table 4. Changes in Hip Adductor Spasticity in the Intervention Group

| Assessment | Knee position | Preinjection | 1st follow-up (3 months after ON block) | 2nd follow-up (6 months after ON block) |
|------------|---------------|--------------|----------------------------------------|----------------------------------------|
| MAS        | Flexion       | 2.38±0.57    | 1.54±0.58*                              | 1.63±0.65                               |
|            | Extension     | 3.35±0.85    | 2.31±0.84*                              | 2.17±0.87*                              |
| MTS R1     | Flexion       | 29.62±13.11  | 43.65±12.29*                            | 40.00±13.35*                            |
|            | Extension     | 10.38±5.82   | 27.31±12.35*                            | 21.67±10.60*                            |
| R2         | Flexion       | 52.88±12.18  | 63.46±12.23*                            | 62.08±11.51*                            |
|            | Extension     | 24.04±8.37   | 39.23±10.93*                            | 38.96±9.67*                             |

MAS, Modified Ashworth Scale; MTS, Modified Tardieu Scale; R1, angle of muscle catch on fastest movement; R2, passive range of motion of hip abduction; ON, obturator nerve. Values are means±SD. Preinjection, baseline data before ON block. *p<0.05 with the paired t-test between preinjection and follow-up.

The effects of the ON block lasted over 6 months in both clinical and hip lateralization. However, it is unknown whether ON block can ultimately prevent the development of hip dislocation in these low-functioning CP children if ON block is repeated every 6 months. Further studies involving long-term follow-up are needed.

This study showed favorable effects of ON block on hip displacement compared to the nonintervention group. In general, early treatment is preferable for maximum responses and prolonged effects. Thus, the favorable effects seen in our study were likely influenced by early intervention during the course of hip displacement. The risk of progressive hip displacement and dislocation is known to be high in patients with poor walking ability, like our patients. Despite the high risk, the lower annual changes in MP until the second follow-up exam in the intervention group suggested that ON block with ethyl alcohol is useful as an early intervention for alleviating progressive hip displacement in these low-functioning children with CP.

This was a retrospective study. As a result, some differences may exist between the two groups in various areas such as economic background, the patient’s general health status, existing family problems, frequency of other treatments, and the parents’ abilities/attitudes about taking care of their child, which may have influenced the outcomes. A further prospective randomized controlled study is needed to avoid this limitation of our study.

In conclusion, compared to initial MPs, the mean MPs at the first follow-up exam was significantly reduced in the intervention group, whereas the MP was significantly increased in the nonintervention group. In addition, the annual changes in MP were lower until the second follow-up exam in the intervention group compared to the nonintervention group. Despite the low functional level of our patients, a favorable effect of ON block with ethyl alcohol for alleviating progressive hip displacement suggests that it is useful as an early intervention for alleviating further hip displacement. The ON block is a helpful alternative intervention, especially when the cost of intervention is a concern or when the total dose of BoNT-A exceeds the maximum dose recommended for multilevel injections.
REFERENCES

1. Cornell MS. The hip in cerebral palsy. Dev Med Child Neurol 1995;37:3-18.
2. Scrutton D, Baird G. Surveillance measures of the hips of children with cerebral palsy. Arch Dis Child 1997;76:381-4.
3. Scrutton D, Baird G, Smeeton N. Hip dysplasia in bilateral cerebral palsy: incidence and natural history in children aged 18 months to 5 years. Dev Med Child Neurol 2001;43:586-600.
4. Morton RE, Scott B, McClelland V, Henry A. Dislocation of the hips in children with bilateral spastic cerebral palsy, 1985-2000. Dev Med Child Neurol 2006;48:555-8.
5. Soo B, Howard JJ, Boyd RN, Reid SM, Lanigan A, Wolfe R, et al. Hip displacement in cerebral palsy. J Bone Joint Surg Am 2006;88:121-9.
6. Yang EJ, Rha DW, Kim HW, Park ES. Comparison of botulinum toxin type A injection and soft-tissue surgery to treat hip subluxation in children with cerebral palsy. Arch Phys Med Rehabil 2008;89:2108-13.
7. Howard CB, McKibbin B, Williams LA, Mackie I. Factors affecting the incidence of hip dislocation in cerebral palsy. J Bone Joint Surg Br 1985;67:530-2.
8. Cooperman DR, Bartucci E, Dietrick E, Millar EA. Hip dislocation in spastic cerebral palsy: long-term consequences. J Pediatr Orthop 1987;7:268-76.
9. de Moraes Barros Fucs PM, Svartman C, de Assumpção RM, Kertzman PF. Treatment of the painful chronically dislocated and subluxated hip in cerebral palsy with hip arthrodesis. J Pediatr Orthop 2003;23:529-34.
10. Reimers J. The stability of the hip in children. A radiological study of the results of muscle surgery in cerebral palsy. Acta Orthop Scand Suppl 1980;184:1-100.
11. Brunner R, Robb JE. Inaccuracy of the migration percentage and center-edge angle in predicting femoral head displacement in cerebral palsy. J Pediatr Orthop B 1996;5:239-41.
12. Broughton NS, Brougham DJ, Cole WG, Menelaus MB. Reliability of radiological measurements in the assessment of the child’s hip. J Bone Joint Surg Br 1989;71:6-8.
13. Faraj S, Atherton WG, Stott NS. Inter- and intra-measurer error in the measurement of Reimers’ migration percentage. J Bone Joint Surg Br 2004;86:434-7.
14. Hågglund G, Lauge-Pedersen H, Wagner P. Characteristics of children with hip displacement in cerebral palsy. BMC Musculoskelet Disord 2007;8:101.
15. Kalen V, Bleck EE. Prevention of spastic paralytic dislocation of the hip. Dev Med Child Neurol 1985;27:17-24.
16. Miller F, Slomczykowski M, Cope R, Lipton GE. Computer modeling of the pathomechanics of spastic hip dislocation in children. J Pediatr Orthop 1999;19:486-92.
17. Jung NH, Heimen F, Westhoff B, Doerderlein L, Reissig A, Berweck S, et al. Hip lateralisation in children with bilateral spastic cerebral palsy treated with botulinum toxin type A: a 2-year follow-up. Neuropediatrics 2011;42:18-23.
18. Graham HK, Boyd R, Carlin JB, Dobson F, Lowe K, Nattrass G, et al. Does botulinum toxin a combined with bracing prevent hip displacement in children with cerebral palsy and “hips at risk”? A randomized, controlled trial. J Bone Joint Surg Am 2008;90:23-33.
19. Akkaya T, Unlu E, Alptekin A, Gumus HI, Umay E, Cakci A. Neurolytic phenol blockade of the obturator nerve for severe adductor spasticity. Acta Anaesthesiol Scand 2010;54:79-85.
20. Kwon JY, Kim JS. Selective blocking of the anterior branch of the obturator nerve in children with cerebral palsy. Am J Phys Med Rehabil 2009;88:7-13.
21. Russell DJ, Rosenbaum PL, Avery LM, Lane M. Gross motor function measure (GMFM-66 & GMFM-88) user’s manual. London: Mac Keith; 2002.
22. Cornell MS, Hatrick NC, Boyd R, Baird G, Spencer JD. The hip in children with cerebral palsy. Predicting the outcome of soft tissue surgery. Clin Orthop Relat Res 1997:165-71.
23. Shore BJ, Yu X, Desai S, Selber P, Wolfe R, Graham HK. Adductor surgery to prevent hip displacement in children with cerebral palsy: the predictive role of the Gross Motor Function Classification System. J Bone Joint Surg Am 2012;94:326-34.
24. Bowen RE, Kehl DK. Radiographic outcome of soft-tissue surgery for hip subluxation in non-ambulatory children with cerebral palsy. J Pediatr Orthop B 2006;15:109-12.
25. Khot A, Sloan S, Desai S, Harvey A, Wolfe R, Graham HK. Adductor release and chemodenervation in children with cerebral palsy: a pilot study in 16 children. J Child Orthop 2008;2:293-9.
26. Silver RL, Rang M, Chan J, de la Garza J. Adductor release in nonambulant children with cerebral palsy. J Pediatr Orthop 1985;5:672-7.
27. Turker RJ, Lee R. Adductor tenotomies in children with quadriplegic cerebral palsy: longer term follow-up. J Pediatr Orthop 2000;20:370-4.
28. Onimus M, Allamel G, Manzone P, Laurain JM. Prevention of hip dislocation in cerebral palsy by early posas and adductors tenotomies. J Pediatr Orthop 1991;1:432-5.
29. Presedo A, Oh CW, Dabney KW, Miller F. Soft-tissue releases to treat spastic hip subluxation in children with cerebral palsy. J Bone Joint Surg Am 2005;87:832-41.
30. Choquet O, Capdevila X, Bennourine K, Feugeas JL, Bringuier-Branchereau S, Manelli JC. A new inguinal approach for the obturator nerve block: anatomical and randomized clinical studies. Anesthesiology 2005;103:1238-45.
31. Mehrholz J, Wagner K, Meissner D, Grundmann K, Zange C, Koch R, et al. Reliability of the Modified Tardieu Scale and the Modified Ashworth Scale in adult patients with severe brain injury: a comparison study. Clin Rehabil 2005;19:751-9.
32. Lonstein JE, Beck K. Hip dislocation and subluxation in cerebral palsy. J Pediatr Orthop 1986;6:521-6.
33. Khalili AA, Harmel MH, Forster S, Benton JG. Management of spasticity by selective peripheral nerve block with dilute phenol solutions in clinical rehabilitation. Arch Phys Med Rehabil 1964;45:513-9.
34. Katz B, Miledi R. The effect of local blockade of motor nerve terminals. J Physiol 1968;199:729-41.
35. Khalili AA, Betts HB. Peripheral nerve block with phenol in the management of spasticity. Indications and complications. JAMA 1967;200:1155-7.
36. Carpenter EB, Seitz DG. Intramuscular alcohol as an aid in management of spastic cerebral palsy. Dev Med Child Neurol 1980;22:497-501.
37. Tardieu G, Tardieu C, Hariga J, Gagnard L. Treatment of spasticity by selective peripheral nerve block with dilute phenol solutions in clinical rehabilitation. Arch Phys Med Rehabil 1964;45:513-9.
39. Jang SH, Ahn SH, Park SM, Kim SH, Lee KH, Lee ZI. Alcohol neurolysis of tibial nerve motor branches to the gastrocnemius muscle to treat ankle spasticity in patients with hemiplegic stroke. Arch Phys Med Rehabil 2004;85:506-8.

40. Chua KS, Kong KH. Clinical and functional outcome after alcohol neurolysis of the tibial nerve for ankle-foot spasticity. Brain Inj 2001;15:733-9.

41. Chua KS, Kong KH. Alcohol neurolysis of the sciatic nerve in the treatment of hemiplegic knee flexor spasticity: clinical outcomes.

42. Kocabas H, Salli A, Demir AH, Ozerbil OM. Comparison of phenol and alcohol neurolysis of tibial nerve motor branches to the gastrocnemius muscle for treatment of spastic foot after stroke: a randomized controlled pilot study. Eur J Phys Rehabil Med 2010; 46:5-10.

43. Tilton AH. Injectable neuromuscular blockade in the treatment of spasticity and movement disorders. J Child Neurol 2003;18 Suppl 1:S50-66.