Comparison of Three Heel Cord Surgeries in Children With Cerebral Palsy

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This nonrandomized prospective descriptive study compared outcomes of three isolated heel cord surgeries in children with spastic diplegia cerebral palsy (CP): (1) heel cord advancement (HCA), (2) heel cord lengthening according to Vulpius (HCL-V), and (3) heel cord lengthening according to White (HCL-W). Thirty-two children were tested prior to and approximately 1 year after undergoing one of the three surgeries. Objective measures were collected for ankle passive and active range of motion, gross motor function measure (GMFM), and gait. All surgeries indicated significant improvements in end range passive and active ankle dorsiflexion, GMFM, and dorsiflexion during gait. Gait speed was significantly improved for the HCA group, but appeared to be the result of maturity. Gait speed for the HCL-V and HCL-W groups was unchanged. The study was the first to directly compare three heel-cord-lengthening surgeries.

\textbf{Key Words}: equinus deformity, gait, gross motor function measure

Equinus deformity is the most common problem in children with cerebral palsy (Banks & Green, 1958). Three surgeries to correct this problem are heel cord lengthening according to Vulpius (HCL-V) (Rosenthal & Simon, 1992), heel cord lengthening according to White (HCL-W) (Graham & Fixsen, 1988), and heel cord advancement (HCA) (Pierrot & Murphy, 1974; Strecker, Via, Oliver, & Schoenecker, 1990; Walker, Stevens, Clark, & Opfell, 1994). Improvements in passive ankle dorsiflexion end range of motion and increases in dorsiflexion during gait have been reported for HCL (Rose, DeLuca, Davis, Ounpuu, & Gage, 1993). However, the surgery was not performed in isolation and thus the influence of the

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other procedures on gait are unknown. Strecker et al. (1990) reported a 98% excellent or good result (4.5-yr follow-up) for correction of equinus deformity in 100 randomly selected patients undergoing HCA surgery. Walker et al. (1994) reported a 65% excellent or good result with the HCA surgery ($N = 90$, at 9.7-yr follow-up) but no longer performed the HCA surgery since they obtained comparable results with simpler HCLs.

In these HCA investigations, a subjective rating scale was used to evaluate the gait of the children. No studies have simultaneously assessed outcomes of HCA and HCL surgeries performed in isolation to determine whether the surgeries do have the same outcome. The purpose of this study was to objectively compare the outcomes of the HCA, HCL-V, and HCL-W surgeries in children with cerebral palsy. It was hypothesized that there would be no differences among surgeries for the outcome measures.

Methods

Thirty-two children with spastic diplegia cerebral palsy, as defined by the Gross Motor Function Classification System (GMFCS) Level I (Palisano, Rosenbaum, & Walter, 1997), were recruited for this study (Table 1). They were recruited through the orthopaedic departments at the Shriners Hospitals for Children in St. Louis, MO, and Lexington, KY, and the St. Louis Children’s Hospital. The general inclusion criteria for considering surgical correction of equinus gait deformity were children less than 10 years of age with spastic diplegia. The equinus deformity was secondary to a variable combination of both triceps surae spasticity and/or equinus contracture.

The children underwent one of three surgeries: (1) heel cord advancement (HCA) (Pierrot & Murphy, 1974), (2) heel cord lengthening-V (HCL-V) (Rosenthal & Simon, 1992), or (3) heel cord lengthening-W (HCL-W). The surgical procedure for each participant was determined by the physician and parents. The HCA and HCL-V surgeries were performed at the St. Louis Hospitals and the HCL-W surgery was performed at the Lexington Hospital. No randomization occurred.

Data from 18 children without disability (nondisabled, ND group) were used for comparison with the CP groups. The ND children were a subset of the St. Louis laboratory normative data base ($n = 44$, mean age 9.3 years, $SD = 4.7$). They were age-matched to the CP groups. Since the HCA group was significantly younger than the HCL-V and HCL-W groups, we created two ND groups (Table 1). The ND-Old group consisted of 14 participants who did not differ significantly in age from

| Table 1 Means and Standard Deviations of Descriptive Data for the 5 Groups |
|-----------------------------|----------------|----------------|----------------|----------------|----------------|
| Sample size                | HCA            | HCL-V          | HCL-W          | ND-Young       | ND-Old         |
| Boys                       | 12             | 10             | 10             | 10             | 14             |
| Girls                      | 7              | 4              | 8              | 5              | 7              |
| Age (years)                | 4.3 ± 0.9      | 6.8 ± 2.0***   | 8.6 ± 3.1***   | 5.5 ± 1.1      | 7.5 ± 2.9      |
| Mass (kg)                  | 17.6 ± 3.4     | 23.2 ± 8.3*    | 27.4 ± 10.7*** | 21.0 ± 5.5     | 30.6 ± 12.9    |

Significantly different from HCA: *$p < 0.05$; ***$p < 0.005$. 
the two HCL groups. The ND-Young group consisted of 10 children who did not differ significantly in age from the HCA group. Six children were included in both groups. All participants and/or parent signed an informed consent approved by the Washington University or University of Kentucky Human Studies Committee.

The procedure describing the specific technique for the HCA surgery has been reported elsewhere and will be briefly outlined here (Pierrot & Murphy, 1974; Strecker et al., 1990; Walker et al., 1994). A posterior longitudinal incision is made to expose the Achilles tendon, which is detached at its insertion on the calcaneal apophysis as far distally as possible. The calcaneal surface just posterior to the subtalar joint is exposed and a hole is drilled through the calcaneus to the plantar surface. A Number 1 PDS suture is placed through the end of the Achilles tendon and then passed anterior to the flexor hallucis longus from a medial to lateral direction and into the hole. The suture is tied over a composite button on the plantar surface of the foot. The degree of tension on the fixed heel cord is tested by passive dorsiflexion with the knee in 90 deg of flexion. If neutral dorsiflexion cannot be obtained, a fractional lengthening of the gastrocnemius is performed.

Postoperatively the patients are placed in a short leg cast and kept non-weight-bearing for 6 weeks. At that time the cast is removed and the patient is placed in an AFO with 10° dorsiflexion/plantarflexion stops. These are worn for 23 of 24 hours for 3 months and then at night for an additional 3 months. At the end of 7 ½ months postoperatively, there is generally no need for bracing.

The HCL-V surgery has been described elsewhere and will be briefly described here (Rosenthal & Simon, 1992). With the patient prone, a longitudinal incision is made in the lower middle region of the calf, avoiding the sural nerve. The fascia over the gastrocnemius muscle is incised, revealing its aponeurosis. A sharp transverse horizontal incision is made in the aponeurosis of the gastrocnemius muscle. The ankle is dorsiflexed enough to reveal the aponeurosis of the soleus muscle, which is then also incised horizontally. In most cases, 1 or 2 aponeurotic bands in the soleus are encountered and are cut. The ankle is then dorsiflexed 5 to 10° in all cases. If resistance is met at neutral, a second aponeurotic cut is made in a similar fashion. The wound is closed with absorbable sutures at all layers and reinforced with steri-strips. The foot is immobilized in a short leg cast with the ankle dorsiflexed 5°, and patients are ambulatory within 1 to 3 days after surgery, whenever possible. Cast immobilization is discontinued at 5 weeks and patients are also fit with an AFO with fixed dorsiflexion and plantarflexion stops.

The technique for the HCL-W surgery has also been described elsewhere (Graham & Fixsen, 1988). The percutaneous Achilles tendon lengthening uses two or three partial transverse cuts to weaken the tendon. Tendon elongation is then achieved by forcefully lengthening the weakened tendon to approximately 5 to 10° of dorsiflexion. A short leg walking cast is applied with the ankle in neutral and maintained for 4 weeks. Walking is encouraged the same day as the surgery as full or assisted weight-bearing. No restrictions are applied. The cast is removed and the patient begins active and passive range of motion exercises full weight-bearing, and use of a hinged AFO with no plantarflexion and free dorsiflexion during the day only.

It should be noted that not only are the surgeries different, so too is the postoperative care. It was decided that the potential influences of the postoperative care could not be parceled out for the groups. Thus the results from each surgery include the individual influences of each surgery and the influences of their respective postoperative care (e.g., orthotics).
The children were tested prior to surgery and then again approximately 1 year after surgery (mean 14 ± 3 months). Data from four different tests were collected: (1) passive range of motion at the ankle, (2) active range of motion at the ankle, (3) gait analysis, and (4) gross motor function measure (GMFM). It should be noted that prior to participant data collection the data were collected in both laboratories on the same volunteer. Results indicated a 5% or smaller difference between laboratories.

Standard goniometry was used to measure ankle dorsiflexion and plantarflexion. The axis of the goniometer was placed just below the lateral malleolus. The proximal arm of the goniometer was aligned with the shaft of the fibula and the distal arm was aligned parallel with the plantar surface of the calcaneus. The 5th metatarsal head, a commonly recommended landmark, was not used for the distal arm of the goniometer in order to avoid overestimating ankle dorsiflexion in the presence of a midtarsal break or rocker bottom foot deformity. Ankle dorsiflexion/plantarflexion was measured with the knee extended to determine gastrocnemius length and with the knee flexed to determine soleus length.

Reflective surface markers were placed bilaterally on each child at: (a) the fifth metatarsal head, (b) the posterior aspect of calcaneus, (c) the lateral malleolus, and (d) the lateral condyle of the femur. A motion-capture video system was used to record the locations of the markers (60 Hz) during the tests. For the tests, each child was seated upright on a table with feet not touching the floor (Engsberg, Ross, & Park, 2004). The child’s leg was supported by a researcher at approx. a 45° angle from the vertical to place the ankle in the child’s view. The child was instructed to actively perform at least 3 repetitions of complete dorsiflexion and plantarflexion. If necessary, a few practice trials preceded data collection. Verbal instructions, tactile cues, demonstrations, and other techniques were used to help the child understand and execute the task. No physical assistance was given during actual data collection. The speed of the movement was self-selected, but any kicking or jerking strategies were not accepted.

Video data from the active ROM tests were tracked to produce locations for the surface markers as a function of time. End-range positions for each movement, trial, and participant were determined and averaged for the ankle joints. It should be noted that a limitation of this test is that other factors not related to the contracture (e.g., neurological components) may inhibit the motion of the child during this test. However, we have assumed that these factors were not altered during the time of participation.

The GMFM is a standard criterion-referenced test designed to assess change in gross motor function in children with CP (Russell, Rosenbaum, & Gowland, 1993). It was designed to measure how much of an activity the child is capable of performing. The 88 items of the test (GMFM-88) assess activities in 5 dimensions: (1) lying and rolling, (2) sitting, (3) crawling and kneeling, (4) standing, and (5) walking, running, and jumping. Each item is scored using a 4-point Likert scale (0 = does not initiate; 1 = initiates; 2 = partially completes; 3 = completes). Totals from each category for a child are divided by the total possible points to produce a category percentage score. These percentages are averaged to yield an overall score. For the present study only the final two dimensions of the GMFM (Section D, standing; and Section E, walking, running, and jumping) were administered. The percentage scores from each dimension were averaged.
Video data from 6 camera HiRes Motion Analysis Corporation systems (Motion Analysis Corp., Santa Rosa, CA) captured the images of 24 reflective surface markers during gait. Three markers were placed on each of the trunk, pelvis, thighs, legs, and feet in a standardized manner (Bassett, Engsberg, McAlister, Gordon, & Schoenecker, 1999; Borrelli, Goldfarb, Ricci, Wagner, & Engsberg, 2002; Engsberg, Lenke, Uhrich, Ross, & Bridwell, 2003; Engsberg, Ross, Collins, & Park, 2005). The child walked barefoot along a 9-m walkway and video data were collected during the middle 2 m. At least 3 trials were collected for each child.

The location-time data of the surface markers were tracked (digitized) and converted to 3-D coordinates as a function of time. The tracked data were processed using standard software (Motion Analysis Corp.). The software produced data describing the averaged joint angle as a function of the complete gait cycle for each of the three principal planes of the body. Six specific variables were determined from these data: (1) dorsiflexion at initial contact, (2) maximum plantarflexion, (3) maximum dorsiflexion, (4) dorsi/plantarflexion ROM, (5) knee flexion at initial contact, and (6) knee flexion minimum. In addition, linear gait variables including speed, stride length, and cadence were determined.

Paired t-tests determined whether there were significant differences between the right and left legs of the CP groups (p < 0.05). Since there were no differences in any of the measures, the right and left sides were averaged (Rosner, 1982). An analysis of variance (ANOVA) with repeated measures was used to test for significant differences within and among groups of children with CP and children without a disability (p < 0.05). A Tukey post hoc test was used to identify the groups that were significantly different (p < 0.05). Only one leg of the children without a disability was evaluated for the active range-of-motion tests. Passive ROM data were not collected from the nondisabled groups, hence previously reported normative data for end-range dorsiflexion with knees flexed and extended were used for statistical comparisons (Tabrizi, McIntyre, Quesnel, & Howard, 2000).

Results

The preoperative passive DF end range of motion both with the knee flexed and extended was significantly less than the nondisabled norms for all 3 groups (Table 2). The values were no longer significantly different from the nondisabled norms, postoperatively. In addition, there was a significant increase in end range of motion from pre- to postoperative for all 3 groups. There were no differences among groups for any of the sessions.

Similarly, the preoperative active DF end range of motion was significantly less than for the nondisabled group for all 3 groups (Table 2). The postoperative values were no longer significantly different from the nondisabled group for the HCA and HCL-V groups, but remained significantly less for the HCL-W group. There was also a significant increase in DF end range of motion from pre- to postoperative for all 3 groups.

The results for preoperative active PF indicated no significant difference for end range of motion compared to the nondisabled groups for the HCA and HCL-V groups, but for the HCL-W groups was significantly greater than for the nondisabled group. None of the surgical groups were significantly different from the nondisabled groups, postoperatively. There was a significant decrease in PF end range of motion from pre- to postoperative for all 3 groups.
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The results for preoperative active total ROM were significantly less than those for the nondisabled group for all 3 groups, and the values remained significantly less, postoperatively. There was a significant increase in ROM from pre- to postoperative for all 3 groups.

The results for the GMFM indicated that the HCA group scored significantly lower than the 2 HCL groups for the 3 categories, preoperatively (Table 3). However, there were no differences between groups postoperatively (Table 3). The HCA group indicated significant improvements pre- to postoperative in all 3 categories. The HCL-V group indicated improvements for the total score, and the HCL-W group indicated improvements for both the standing and total categories.

Gait speed was not significantly different from nondisabled for any of the groups, regardless of session (Table 4). The HCA group indicated a significant increase in speed from pre- to postoperative, whereas the HCL groups had no change in speed as a consequence of the surgery. Cadence was significantly greater for the HCA group compared to the nondisabled group both pre- and postoperatively, but was not different from nondisabled for the other 2 groups. Stride length was significantly less than in nondisabled for the HCA group, preoperatively, but was not different at the postoperative session. In addition, there was a significant increase in stride length from pre- to postoperative for the HCA group. Preoperative stride length was not different from that of the nondisabled group for both HCL groups, and there was no change postoperative.

All 6 gait kinematic variables—(1) dorsiflexion at initial contact, (2) maximum plantarflexion, (3) maximum dorsiflexion, (4) dorsi/plantarflexion ROM, (5)
Postoperatively, the 2 knee flexion variables and the dorsi/plantarflexion ROM remained significantly different. There were significant improvements for the remaining 3 ankle variables (dorsiflexion at initial contact, dorsiflexion maximum, and plantarflexion maximum), and these variables were no longer different from nondisabled.

Dorsiflexion at initial contact, dorsiflexion maximum, and plantarflexion maximum indicated a significant increase following the surgery.

Five of the 6 gait kinematic variables for the HCL-V group were significantly different from nondisabled, preoperatively (Table 5). Postoperatively, the 2 knee flexion variables and the dorsi/plantarflexion ROM remained significantly different. There were significant improvements for the remaining 3 ankle variables (dorsiflexion at initial contact, dorsiflexion maximum, and plantarflexion maximum), and these variables were no longer different from nondisabled.

Five of the 6 gait kinematic variables for the HCL-V group were significantly different from nondisabled, preoperatively, with only knee flexion minimum not being different. Postoperatively, knee flexion at initial contact and dorsiflexion at initial contact remained different, while dorsiflexion maximum, plantarflexion maximum, and dorsi/plantarflexion ROM were no longer different from nondisabled. Dorsiflexion at initial contact, dorsiflexion maximum, and plantarflexion maximum indicated a significant increase following the surgery.
Three of the 6 gait kinematic variables for the HCL-W group (knee flexion at initial contact, dorsiflexion at initial contact, dorsi/plantarflexion ROM) were significantly different from nondisabled, preoperatively, with knee flexion minimum, dorsiflexion maximum, and plantarflexion maximum not being different. Postoperatively, knee flexion at initial contact and dorsiflexion maximum remained different, while knee flexion minimum, dorsiflexion at initial contact, plantarflexion maximum, and dorsi/plantarflexion ROM were no longer different from nondisabled. Knee flexion at initial contact, dorsiflexion at initial contact, and plantarflexion maximum indicated a significant increase following the surgery. Numerous differences existed between HCL-W group and the HCL-V and HCA groups. For example, preoperative dorsiflexion at initial contact was about $-25^\circ$ for both the HCA and HCL-V groups, but only $-9^\circ$ for the HCL-W group.

**Discussion**

This study objectively compared the outcomes of the HCA, HCL-V, and HCL-W surgeries in children with cerebral palsy. Besides the group difference in postoperative care that was identified in the Methods, there are at least 3 additional limitations associated with this investigation. The results must be weighed relative to these
limitations. The first is that the children were not randomly assigned to the surgical group. The lack of randomization is due to numerous factors including: surgeon and parent preference, participant age, hospital philosophy, and randomization to an irreversible procedure. Nevertheless, the present study was the first, to our knowledge, to prospectively examine the 3 different surgeries without concurrent additional procedures.

The second limitation is that the children in the HCA group were significantly younger than those in the 2 HCL groups. The younger age of the HCA group is a result of surgeon preference for using the HCA surgery. They typically perform the HCA surgery on children ages 3–7, and the HCL-V surgery on children older than 7 years. How this age difference affects the results for the different tests of the present study is not always clear. For example, the preoperative GMFM results indicated that both HCL groups scored significantly higher than the HCA group. Initially it could be concluded that the HCA group was selected from a group with greater disability than those selected for the HCL groups. However, recently published regression equations describing the natural improvement in GMFM scores due to maturation indicates that the participants may be from the same group, i.e., no difference in disability, but are just at an earlier time point in their development (Palisano, Hanna, Rosenbaum, et al., 2000).

The regression equations indicate that for GMFCS Level I, preoperatively at the age of 4.3 years (i.e., mean preoperative age of the HCA group) an increase of about 6 points on the GMFM % score would be expected by the time the child reaches 6.8 years of age (i.e., mean preoperative age of the HCL-V). An increase of about 7 points would be expected by the time the child attained 8.6 years of age (i.e., mean preoperative age of the HCL-W group). These values differ by only 2 percentage points from the actual preoperative means for the GMFM scores for the HCL-V and HCL-W groups (i.e., 97) and are well within the 95% confidence bounds. Thus it would appear that the lower preoperative score of the HCA group is likely due to their younger age than to a greater level of disability.

The third limitation is sample size. The study was originally designed for a \( p \) value < 0.05 for committing a Type I error and a power \((1-\beta)\) of 0.80 for committing a Type II error for the variables of gait speed and GMFM variables (Lieber, 1990). The power analysis led to a sample size of 12 participants per group. Recruitment issues and attrition led to lower than targeted sample sizes in the HCA-V \((n = 10)\) and HCL-W \((n = 10)\) groups.

All three surgeries were effective in increasing dorsiflexion end range of motion. In fact, dorsiflexion end range of motion was significantly improved both passively with knees flexed and extended, as well as actively under the control of the participant. All three surgeries also significantly decreased the plantarflexion end range of motion, as the surgeries for the most part shift the existing range more toward dorsiflexion. The result for end-range passive dorsiflexion range of motion with knee flexed was similar to previously reported results (preoperative, 4° ± 13; postoperative, 11° ± 10) (Rose et al., 1993). However, the pre- and postoperative results for end range of motion with knee extended in the present study were much less in magnitude than the 3 surgeries of another study examining HCL surgery performed on independent ambulators (preoperative, –41° ± 19; postoperative, –23° ± 15) (Rose et al., 1993). Further, the change from pre- to postoperative was much less for the HCA and HCL-V of the present study, but about the same for the HCL-W of this study. An explanation for the differences is difficult to determine, as it
appears the surgical methods described in the previous publication were similar to those of the present study. All three groups indicated improvements in overall motor function with significant increases in the GMFM scores. The improvements for each group (HCA group improved 4 points, HCL-V and HCL-W groups improved 1 point) easily fell within the gains that would be expected for the respective age groups and GMFCS Level I over a 1-year period (Palisano et al., 2000). Using the regression for GMFCS Level I, for children with an average age of 4.3 years (HCA group), an improvement of about 4 points would be expected over a 1-year period. Using the regression for GMFCS Level I, for children with an average age of 6.8 years (HCL-V group), an improvement of about 2 points would be expected over the year. Finally, for children with an average age of 8.6 years (HCL-W group), an improvement of about 0.5 points would be expected. It should be noted that the sample from which the Palisano et al. (2000) regression equations were drawn excluded children who had a selective dorsal rhizotomy surgery, intrathecal baclofen, or botulinum toxin injections to the lower limbs. It is therefore assumed that participants having prior orthopedic surgeries were permitted in the study, and the participants from the present study are following along the same path as those of the Palisano group (Palisano et al., 2000).

The HCA was the only group that significantly improved in their gait speed (28 cm/s), primarily due to an increase in stride length since there was no change in cadence. The 2 HCL groups demonstrated no significant changes in gait speed. It was not entirely clear whether the improvement observed for the HCA group was due to the surgery, a result of increasing age, or a combination of the two. No published data exist regarding changes in gait speed as a consequence of increased age for children with CP. However, we have reported gait speed data obtained from a group of children with CP at an initial test and at 8 and 20 months later (Engsberg et al., 2005). This group of children did not undergo any procedure during that 20-month period other than their typical physical therapy 0–2 times a week. A subgroup of 6 children (GMFCS Level I) with an average age of 4.6 ± 0.5 years walked at 71 ± 14, 92 ± 27, and 109 ± 10 cm/s at the 3 test sessions, respectively. Interpolation of these data at a 12-month interval yielded a gait speed of 97 cm/s for an increase speed of about 26 cm/s over the 1-year period. Thus it would appear that the increase in gait speed for the HCA group (i.e., 28 cm/s) was likely due to maturation and not the surgery, and their results are similar to those of the HCL groups.

All 3 groups indicated improvements (i.e., change toward values of ND group) in gait kinematics. Each group demonstrated significant improvements in dorsiflexion at initial contact and plantarflexion maximum. The HCA and HCL-V groups indicated significant improvement in dorsiflexion maximum, while the HCA-W group indicated a significant improvement in knee flexion at initial contact. Previously reported results for ankle dorsiflexion at initial contact (preoperative, −5° ± 10; postoperative, −3° ± 7) were substantially less than those reported for the HCA and HCL-V of the present study. They were slightly less than the result for the HCL-W group. Differences could be due to a host of factors primarily centered around how the data were collected (e.g., marker placement). Previously reported results for knee flexion at initial contact (preoperative, 25° ± 10; postoperative, 16° ± 6) were about the same for the 3 surgeries of the present study. It should be noted that the changes described here are not relevant to children of similar age without
disability, since it has been reported that mature gait is developed by 4 years of age (e.g., Beck, Andriacchi, Kuo, Fermier, & Galante, 1981).

The decision as to which surgery to perform is a multifactorial issue and must be carefully considered for each patient. These factors include: patient age, time required to perform the surgery, surgical complications, postoperative recovery time and therapy, likelihood of repeating the surgery, surgeon, and hospital preference. For example, the HCA technique was historically developed by surgeons at the Lexington Shrine Hospital in the 1970s (Pierrot & Murphy, 1974). Similarly, the surgeons at the St. Louis Shrine Hospital began utilizing the HCA operation for children with equinus deformity gait who either had proven or potentially good independent ambulatory function. HCA was selected preferentially over either the HCL-W or the HCL-V in hopes of minimizing the recurrence of equinus deformity severe enough to warrant repetitive heel cord lengthening surgery. From early experience in St. Louis, generally excellent functional outcome was reported with minimal need for repeat surgical correction, which is sometimes the case in the HCL surgery (Strecker et al., 1990).

The present investigation was the first to directly compare 3 isolated heel cord lengthening surgeries for children with cerebral palsy. It is concluded that all 3 surgeries appear effective in increasing dorsiflexion range of motion, improving GMFM scores, and increasing dorsiflexion during gait. Future studies should include the rate of repeat surgeries for these groups.

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References


