Achievement of Gross Motor Milestones in Children With Idiopathic Clubfoot Treated With the Ponseti Method

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Background: The Ponseti method of idiopathic clubfoot treatment involves a series of weekly casts, a percutaneous Achilles tenotomy if needed, followed by wearing a foot abduction orthosis (FAO). Gross motor development of children with idiopathic clubfoot has not been examined. The purposes of this study were to determine the ages of achievement of gross motor milestones in children with clubfoot treated with Ponseti method and to compare those ages with historical normative developmental data.

Methods: In this prospective study, 51 children with idiopathic clubfoot who had their first cast applied when ≤90 days old, were full-term with no other orthopaedic conditions or previous clubfoot treatment, and were compliant with wearing FAO were enrolled. Parents were interviewed repeatedly to acquire the ages of achievement of 8 gross motor milestones.

Results: Fifteen children were excluded for reasons such as noncompliance with FAO, and not returning for follow-up. Thirty-six children, mean age of 15.2 days at first casting, achieved rolling prone to supine at a mean age of 5.1 months, rolling supine to prone at 5.1 months, sitting without support at 6.6 months, crawling on hands and knees at 8.6 months, pull-to-stand at 9.0 months, cruising at 10.2 months, and ambulating independently at 13.9 months. When compared with previously published values for unaffected children, the mean ages of achievement for 6 of 8 milestones were significantly greater (P < 0.05) for the children with clubfoot. The preambulatory milestones were achieved from 0.7 to 1.5 months later and independent ambulation up to 2.2 months later. Fifty percent of children with clubfoot were ambulating at 13.8 months; 90% at 17.7 months.

Conclusions: Minimal delays in gross motor milestone achievement were found in children with idiopathic clubfoot treated with the Ponseti method. Delays were, at most, 1.5 months, except for independent ambulation, which was approximately 2 months. These findings should enable pediatric clinicians to alleviate the concerns of parents of children with idiopathic clubfoot regarding gross motor milestone achievement.

Level of Evidence: Therapeutic Level II.

Key Words: clubfoot, milestones, Ponseti, ambulation, pediatric

Since the late 1990s, the Ponseti method has been the primary treatment for idiopathic clubfoot at our facility. It involves a series of casts that are changed weekly including a percutaneous Achilles tenotomy (PAT) if needed, and then the use of a foot abduction orthosis (FAO) for a minimum of 3 years.

Parents of children with idiopathic clubfoot often express concerns about their child’s gross motor development. Although clubfoot and its treatment have not been observed to prevent ambulation, the age at which ambulation and other gross motor milestones are achieved in children with idiopathic clubfoot has not been systematically examined. Unaffected children have been found to ambulate independently at an average age of 11.72 or 12.2 months3 and 50% ambulate by 12.3 months4.

The purposes of the present study were to determine the ages at which children with idiopathic clubfoot treated with the Ponseti method achieved gross motor milestones and to compare those ages with historical normative developmental data.

METHODS

From September 2005 to November 2009, 57 consecutive children presented with idiopathic clubfoot, were treated with the Ponseti method and met the inclusion criteria in this IRB-approved study. Inclusion criteria were no other orthopaedic conditions (eg, torticollis, hip dysplasia), full-term (≥37 wk gestation), no previous clubfoot treatment, ≤90 days old at application of the first cast, and compliance with the FAO wearing schedule until the time of independent ambulation. The Ponseti method consisted of the application of long leg casts changed weekly for approximately 2 months and a PAT if the ankle could not be dorsiflexed to 20 degrees before the final cast. After removal of the final cast that was worn for 3 weeks, the FAO was used full-time (23 h/d) for
3 months and then, during nap-time/night-time (8 to 10 h/d).

Each child's chart was reviewed for age at time of first cast application, gender, unilateral or bilateral involvement, number of casts applied, and whether a PAT was performed.

Beginning when their child was 4 to 5 months old, parents were interviewed at each clinic visit regarding the age at which their child achieved 8 gross motor milestones until the child ambulated independently. The milestones were: (1) roll prone to supine, (2) roll supine to prone, (3) sit without support, (4) crawl on stomach, (5) crawl on hands and knees, (6) pull-to-stand, (7) cruising (walking sideways while holding onto furniture), and (8) independent ambulation (10 steps without support). Illustrations and demonstrations were provided to clarify the motor skill when needed. The age of milestone achievement to the nearest month and the number of interviews per parent were recorded.

**Statistical Analysis**

The mean and range for the age at the time of the application of the first cast, the number of casts, and the number of interviews per parent were calculated. The frequency and percentage were determined for gender, bilateral and unilateral clubfoot, and performance of PAT. The one-sample t test was used to compare the mean age of achievement of each of the milestones in the sample to the means from 2 studies of unaffected children.2,3 A P-value < 0.05 was considered statistically significant. Post hoc power analyses of the one-sample t tests were performed.

The 50th, 75th, and 90th percentiles for the age of achievement of pull-to-stand and independent ambulation for the children with clubfoot were compared with the ages reported for unaffected children on the Denver II,4 which is a standardized developmental screening test. These were the only 2 studied milestones included on the Denver II.

**RESULTS**

Five of the 57 children who met the inclusion criteria were not enrolled because they did not return for follow-up, moved, or switched their care to another facility because of insurance issues. In addition, 1 family was not interested in participating.

For the 51 children who were enrolled, 15 were not included in the data analysis for the following reasons: 6 were noncompliant with the FAO wearing schedule, 5 stopped returning for follow-up before ambulating independently, 2 were receiving parent-arranged physical therapy, 1 was subsequently diagnosed with global developmental delay, and 1 was treated with a modification of the typical protocol. The latter child experienced recurrence of his clubfoot deformities after 4 months of compliant FAO wear, and required recasting, PATs, and return to full-time FAO use.

Thirty-six children (53 feet) were included in the data analysis. The mean age at the time of the first cast application was 15.2 days (range, 2 to 90 d). Twenty-five (69%) were males and 11 (31%) were females. Nineteen (53%) were affected unilaterally and 17 (47%) bilaterally. The mean number of casts was 5.3 (range, 3 to 8) with 31 of the 53 feet (59%) requiring a PAT. The mean number of interviews per parent was 4.7 (range, 3 to 7).

The ages of achievement for 6 of the 8 milestones were significantly higher (P < 0.05) for the children with clubfoot than the unaffected children in at least 1 of the 2 comparison studies2,3 (Table 1). The children with clubfoot rolled prone to supine 0.7 to 1.5 months later, sat without support 1.4 months later,2 crawled on hands and knees 0.8 months later,2 pulled to stand 0.9 months later,2 cruised 1.4 months later,2 and ambulated independently 1.72 to 2.2 months later than the unaffected children. The 2 milestones that were not significantly delayed for the study group compared with the 2 unaffected groups were rolling supine to prone (P = 0.2322; P = 0.7453) and crawling on stomach (P = 0.2312; P = 0.1313).

For pull-to-stand and independent ambulation, the 50th, 75th, and 90th percentile ages of achievement were higher for the clubfoot group than the unaffected group from the Denver II4 (Table 2). Fifty percent of the children with clubfoot were ambulating independently at 13.8 months compared with 12.3 months for the unaffected children. Ninety percent of the clubfoot group was ambulating independently at 17.7 versus 14.9 months for the unaffected group.

Post hoc power analysis of the one-sample t test for independent ambulation, the variable of primary interest, using α = 0.05, current study sample size of 36, and

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Present Study</th>
<th>Capute2</th>
<th>Davis3</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Range</td>
</tr>
<tr>
<td>Roll prone to supine</td>
<td>5.1</td>
<td>1.6</td>
<td>2.0-8.5</td>
</tr>
<tr>
<td>Roll supine to prone</td>
<td>5.1</td>
<td>1.3</td>
<td>3.0-7.5</td>
</tr>
<tr>
<td>Sit without support</td>
<td>6.6</td>
<td>1.3</td>
<td>4.5-9.5</td>
</tr>
<tr>
<td>Crawl on stomach</td>
<td>7.1</td>
<td>1.7</td>
<td>3.8-10.0</td>
</tr>
<tr>
<td>Crawl on hands and knees</td>
<td>8.6</td>
<td>1.9</td>
<td>5.0-14.0</td>
</tr>
<tr>
<td>Pull-to-stand</td>
<td>9.0</td>
<td>1.9</td>
<td>4.8-13.5</td>
</tr>
<tr>
<td>Cruising</td>
<td>10.2</td>
<td>2.0</td>
<td>5.0-14.5</td>
</tr>
<tr>
<td>Independent ambulation</td>
<td>13.9</td>
<td>2.2</td>
<td>9.0-20.0</td>
</tr>
</tbody>
</table>

NR indicates not reported.
current study effect size ($d$) = 1.0 for comparison with Capute et al. and $d = 0.77$ with Davis et al. demonstrated power to be >0.99 and 0.99, respectively. For the other significantly different variables, power ranged from 0.69 to 0.99 ($d$ range, 0.42 to 1.08). For the not significantly different variables, power ranged from 0.05 to 0.40 ($d$ range, 0.08 to 0.29).

### DISCUSSION

The presence of unilateral or bilateral clubfoot does not usually prevent independent ambulation in young children. The treatment of clubfoot using the Ponseti method interferes with normal developmental movements, first with the long leg casts, and subsequently with the FAO. However, the relative contribution of the immobilization of the lower extremities in the casts, the inhibition of independent lower extremity motion in the FAO, and the clubfoot condition itself to the time of achievement of gross motor milestones cannot be determined. Therefore, the present study sought only to ascertain the ages at which the milestones were achieved and if they were delayed when compared with historical norms.

To mitigate the influence of potentially confounding variables, the children had to have been full-term, have idiopathic clubfoot with no other orthopaedic conditions or developmental delays, have no previous clubfoot treatment, have the Ponseti casting started in early infancy, have only 1 series of casts with or without a PAT, and have been compliant with the FAO wearing schedule. Children receiving physical therapy were excluded, as the therapy may have affected their milestone acquisition.

The characteristics of the children in the present study were similar to those of the greater population of children with clubfoot treated with the Ponseti method. For gender distribution, 69% were male, which was comparable with other authors’ values of 63% to 76%. Forty-seven percent of the cases were bilateral, falling within the 26% to 69% range described previously. The mean number of casts, 5.3, was similar to the means, 4.2 to 7, found in earlier studies. A PAT was performed in 59% of the feet, a slightly lower rate than the reported 63% to 91%. The division of the current sample on the basis of unilateral versus bilateral involvement, whether or not had a PAT, and gender would provide additional interesting information. However, this would result in too small of sample sizes in each of the groups to perform meaningful statistical analyses.

Other authors have found discrepancies between actual and recalled ages of milestone achievement and that the reliability of the recalled age decreases as the lapse of time increases. To maximize the accuracy of the reported age in the present study, the parents were interviewed multiple times to minimize the length of time between achievement of a milestone and parental report.

Two of the more recent studies were used to provide the mean ages for unaffected children. In 1985, Capute et al. determined the age of achievement of gross motor milestones, including all 8 in the present study, in 381 unaffected children via parental interview at frequent well-baby visits. The children with clubfoot achieved 5 of the 8 milestones at a significantly later age than these unaffected children.

In 1992, the American Academy of Pediatrics recommended that infants be placed supine or on their side to sleep. Davis et al. subsequently in 1998, examined 7 of the 8 studied milestones in 351 unaffected children whose parents were contacted by phone monthly. These authors found that their subjects who were positioned in supine to sleep attained milestones at a later age than their subjects who continued to be positioned in prone to sleep as all parents did not follow the recommendation. This may explain the slightly higher mean ages for Davis and colleagues than Capute and colleagues for most of the milestones. When compared with the mean ages for the entire sample of Davis and colleagues, the children with clubfoot in the present study showed significant delays in the mean ages of achievement of 3 of the milestones.

The Denver II, a standardized developmental screening test, is frequently used by pediatricians to evaluate children’s development and provides age norms at which 50%, 75%, and 90% of children attain a particular milestone. The ages for the children with clubfoot were older compared with the Denver’s norms for all of the percentiles for pull-to-stand and ambulation.

Although the average ages for achieving 6 of the 8 milestones were statistically significantly later for the children with clubfoot than the unaffected children, the pre-ambulatory milestones were only delayed by, at most, 1.5

### TABLE 2. Percentiles for Ages of Milestone Achievement (mo)

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Present Study</th>
<th>Denver II</th>
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<tbody>
<tr>
<td></td>
<td>50%</td>
<td>75%</td>
</tr>
<tr>
<td>Pull-to-stand</td>
<td>8.8</td>
<td>10.5</td>
</tr>
<tr>
<td>Independent ambulation*</td>
<td>13.8</td>
<td>15.0</td>
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*Present study = 10 steps; Denver II = walk well.
months and independent ambulation by, at most, slightly over 2 months. In addition, half of the children with clubfoot were walking by 14 months and the majority by 18 months. These minimal delays should enable pediatric clinicians to alleviate the concerns of parents of children with idiopathic clubfoot treated with the Ponseti method regarding the achievement of gross motor milestones.

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REFERENCES