Incapacitating articular sequelae in the hip joint have been described for patients with late effects of poliomyelitis. In these patients, total hip arthroplasty (THA) has been associated with a substantial rate of dislocation. This study was conducted to evaluate the long-term clinical and radiologic outcomes of unconstrained THA in this specific group of patients. The study included 6 patients with ipsilateral polio who underwent primary THA between 1985 and 2006. Patients with polio who underwent THA on the nonparalytic limb were excluded. Mean follow-up was 119.5 months (minimum, 84 months). Clinical outcomes were evaluated with the modified Harris Hip Score (mHHS) and the visual analog scale (VAS) pain score. Radiographs were examined to identify the cause of complications and determine the need for revision surgery. All patients showed significantly better functional results when preoperative and postoperative mHHS (67.58 vs 87.33, respectively; $P=0.002$) and VAS pain score (7.66 vs 2, respectively; $P=0.003$) were compared. Although 2 cases of instability were diagnosed, only 1 patient needed acetabular revision as a result of component malpositioning. None of the patients had component loosening, osteolysis, or infection. Unconstrained THA in the affected limb of patients with poliomyelitis showed favorable long-term clinical results, with improved function and pain relief. Nevertheless, instability may be a more frequent complication in this group of patients compared with the general population. [Orthopedics. 2017; 40(2):e255-e261.]

Preferently endemic in Argentina, poliomyelitis is an infectious disease that is caused by poliovirus. It affects the central nervous system and leads to varying degrees of flaccid paralysis. Spinal polio, the most common form of paralytic poliomyelitis, results from viral invasion of the anterior horn cells of the spine and causes asymmetric muscular weakness that is more severe in the proximal lower extremity. Incapacitating articular sequelae have been described in the hip joint of patients with late effects of poliomyelitis. The typical pattern of muscle imbalance involves an unstable ball-and-socket joint similar to what is seen in hip dysplasia. Partial or complete atony of the abductors and extensors, with nearly normal hip flexors and adductors, leads to progressive coxa valga, with proximal femoral deformity and superolateral subluxation over a shallow acetabulum. In this scenario, degenerative disease occurs when an already hypertrophied labrum does not compensate for hip instability, exposing the articular cartilage to forces beyond its tolerance.

In patients with neuromuscular disease, total hip arthroplasty (THA) has been associated with a substantial rate
of dislocation. Constrained acetabular components protect against dislocation in neuromuscularly challenged patients at a minimum 5-year follow-up. However, this stability may be counterbalanced by an increase in acetabular loosening in patients with abnormal muscular tone.

To the authors’ knowledge, only a few case reports and a small case-control series have described the short- and medium-term outcomes of unconstrained primary THA in patients with ipsilateral residual poliomyelitis. This study evaluated the long-term clinical and radiologic outcomes of unconstrained THA in this specific group of patients.

**Materials and Methods**

After approval was obtained from the research ethics board at the study institution, the authors retrospectively analyzed a series of 13 patients with a diagnosis of poliomyelitis who underwent hip surgery between January 1985 and December 2006. In all cases, poliomyelitis was unilateral. Excluded from the study were 4 patients who underwent THA of the nonparalytic hip, 1 patient who underwent revision THA after the primary procedure was performed at another institution, 1 patient with undisplaced femoral neck fracture treated with internal fixation with cannulated screws, and 1 patient with primary THA of the paralytic hip with less than 2 years of follow-up. Therefore, only 6 patients (4 women) who had primary THA of the paralytic limb and a minimum follow-up of 5 years were included.

All surgeries were performed by 1 of 2 experienced hip reconstructive surgeons (M.A.B., F.P.). All patients had spinal anesthesia. In all but 1 case, THA was performed through a posterolateral approach, with the patient in the lateral decubitus position. The remaining patient underwent surgery with a transtrochanteric approach in the dorsal decubitus position. The rehabilitation protocol consisted of partial weight bearing with crutches during the first 2 postoperative weeks, with fixed range of motion exercises at 90° flexion, neutral internal rotation, 30° external rotation, and 45° abduction for 3 to 6 weeks. Return to the previous level of activity was indicated at 4 to 6 months, depending on the muscular strength gained. Use of a postoperative hip abduction brace for 1 month was indicated without a standardized protocol.

Demographic characteristics as well as functional and radiologic outcomes were obtained from the medical records of the prospectively collected database, which had been digitalized since 2003. These data were reviewed by 3 investigators (P.A.S., A.M.G.M., F.M.C.), 2 of whom were not involved in the original patient care (P.A.S., A.M.G.M.).

A thorough physical examination was performed preoperatively, with special attention to motor testing of the hip abductor. The Medical Research Council scale was used to grade muscle strength, ranging from M0 to M5 (M3=active movement against gravity; M4=active movement against gravity and resistance; and M5=normal power). Without a standardized protocol, the primary surgeons recommended surgical treatment when muscle strength of at least M3 was detected. General indications for surgical treatment consisted of symptomatic osteoarthritis of the hip with no response to conservative treatment for at least a 3-month period, including 6 weeks of neurophysical therapy. The modified Harris Hip Score (mHHS) and the visual analog scale (VAS) pain score were used to assess clinical outcomes. Intraoperative and postoperative complications were computed, regardless of whether they were related to the surgical procedure, as previously described by Saleh et al. Additionally, revision surgery was defined as reoperation performed to correct undesirable sequelae of a previous surgery, with or without addition or removal of implant components.

Radiologic evaluation was performed through profound analysis of an anteroposterior radiograph of the pelvis, a modified Dunn’s lateral view (hip in 45° flexion, foot in neutral rotation), and a false profile view. The grade of hip dysplasia was determined according to the Hartofilakidis classification, the lateral center-edge angle of Wiberg, and the Crowe classification. The grade of preoperative osteoarthritic degeneration was categorized with the Tönnis classification. Desirable implant alignment and positioning were defined as outlined previously. Component loosening over time was evaluated according to DeLee and Charnley and Gruen et al by comparing the immediate postoperative radiograph with the radiograph obtained at last follow-up.

Continuous variables were expressed as mean and range or SD. The Mann-Whitney U test was used for continuous variables, and Fisher’s exact test was used for categorical variables. P <0.05 was considered statistically significant. No survival analysis was performed because of the small size of the series. Statistical analysis was conducted with R software, version 2.7.0 (GNU; PSPP, Auckland, New Zealand).

**Results**

After the selection criteria were applied, a total of 6 patients (4 women) with asymmetric poliomyelitis underwent ipsilateral THA, with average follow-up of 119.5 months (range, 84-144 months). Average age at surgery was 51.33 years (±15.24 years). Overall body mass index was 25.83 kg/m² (±4.87 kg/m²). Preoperatively, the mean center-edge angle was 4.33° (±8.68°) on standard radiographic evaluation. Likewise, 3 patients were classified as Crowe grade 2, 2 were classified as Crowe grade 3, and 1 was classified as Crowe grade 4. Three cases were graded as Hartofilakidis classification B, 2 were graded as Hartofilakidis classification A, and 1 was graded as Hartofilakidis classification C. Of the 6 patients, 5 were classified as Tönnis grade 3, and the remaining 1 was classified as Tönnis grade 2. In addition, 1 patient had 2 previous ipsilateral hip procedures (femo-
ral neck varus osteotomy and Chiari pelvic osteotomy) (Figure), and 2 patients had undergone Achilles tendon lengthening during adolescence (Table 1).

All patients underwent primary hip arthroplasty between January 1998 and June 2006. Of these procedures, 4 were cemented (bearing surface, metal on polyethylene), 1 was hybrid (bearing surface, ceramic on ceramic), and 1 was cementless (bearing surface, ceramic on ultra-high-molecular-weight polyethylene with posterior rim), as shown in Table 2.

Patient 1 was a 49-year-old man who underwent cementless THA because of progression of symptoms (preoperative VAS pain score, 9; preoperative mHHS, 61.6) after both femoral neck varus osteotomy and Chiari pelvic osteotomy during adolescence. At 128 months of follow-up after THA, the symptoms dramatically improved (postoperative VAS pain score, 1; postoperative mHHS, 90.5).

Patient 2 was a 65-year-old woman with advanced secondary osteoarthritis (Tönnis grade 3) of the left hip. Preoperative mHHS was 70, and preoperative VAS pain score was 8. The patient had anterior instability 13 months after hybrid THA. After revision surgery, mHHS and VAS

<table>
<thead>
<tr>
<th>Patient No./Sex/Age at Surgery, y</th>
<th>Body Mass Index, kg/m²</th>
<th>Side</th>
<th>Tönnis Grade</th>
<th>Crowe Grade</th>
<th>Angle of Wiberg</th>
<th>Hartofilakidis Classification</th>
<th>Hip Abductor Strengtha</th>
<th>Previous Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/49</td>
<td>22</td>
<td>R</td>
<td>2</td>
<td>3</td>
<td>4°</td>
<td>B</td>
<td>3</td>
<td>Chiari pelvic osteotomy+femoral varus osteotomy</td>
</tr>
<tr>
<td>2/F/65</td>
<td>19</td>
<td>L</td>
<td>3</td>
<td>3</td>
<td>10°</td>
<td>B</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>3/F/70</td>
<td>30</td>
<td>R</td>
<td>3</td>
<td>2</td>
<td>15°</td>
<td>A</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>4/F/51</td>
<td>25</td>
<td>L</td>
<td>3</td>
<td>4</td>
<td>-10°</td>
<td>C</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>5/M/27</td>
<td>27</td>
<td>L</td>
<td>3</td>
<td>2</td>
<td>B</td>
<td>4</td>
<td>Achilles tendon lengthening</td>
<td></td>
</tr>
<tr>
<td>6/F/46</td>
<td>32</td>
<td>R</td>
<td>3</td>
<td>2</td>
<td>0°</td>
<td>A</td>
<td>4</td>
<td>Achilles tendon lengthening</td>
</tr>
</tbody>
</table>

Abbreviations: F, female; L, left; M, male; R, right.
aMedical Research Council scale.
pain score at final follow-up were 75 and 5, respectively.

Patient 3 was a 70-year-old woman who had mild dysplasia (Hartofilakidis classification A, Crowe grade 2) of the right hip that evolved to progressive degenerative destruction (Tönnis grade 3). The patient underwent cemented THA with bone allograft fixed with a mesh and 3 bone screws to reconstruct the acetabular roof. At 144 months of follow-up, the patient showed improvement of symptoms (mHHS, 66.5 preoperatively vs 92.5 postoperatively) and VAS pain score (7 preoperatively vs 1 postoperatively). The patient had no signs of component loosening or allograft resorption.

Patient 4 was a 51-year-old woman with severe hip dysplasia (Hartofilakidis classification C, Crowe grade 4). She underwent cemented THA without the need for bone allograft. At final follow-up, clinical scores showed marked improvement (mHHS, 68.5 preoperatively vs 82.5 postoperatively; VAS pain score, 8 preoperatively vs 2 postoperatively).

All patients showed significantly better functional results when preoperative and postoperative mHHS (67.58 vs 87.33, respectively; $P=0.002$) and preoperative and postoperative VAS pain score were compared (7.66 vs 2, respectively; $P=0.0003$). At last follow-up, all patients used assisted walking devices (cane, walker, or crutches) with full weight bearing to aid in mobility.

As shown in Table 3 and mentioned previously, 2 cases of instability were found. One was anterior subluxation that was diagnosed at 13-month follow-up secondary to a vertically positioned acetabular cup that required 1-time acetabular component revision. The other was an isolated posterior dislocation noted at 36-month follow-up, with no radiologic signs of component malpositioning, that was treated with closed reduction. The dislocation did not recur. No patient was diagnosed with either component loosening or osteolysis or infection.

**Discussion**

In patients with residual poliomyelitis, THA of the paralytic limb is unusual.

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### Table 2

**Implant Selection and Follow-up**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Type of Prosthesis</th>
<th>Acetabular Component</th>
<th>Stem</th>
<th>Head Size, mm</th>
<th>Bearing Surface</th>
<th>Follow-up, mo</th>
<th>Walking Aid at Last Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cementless</td>
<td>Duraloc</td>
<td>S-ROM</td>
<td>32</td>
<td>Ceramic on ultra-high-molecular-weight polyethylene with posterior rim</td>
<td>128</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Hybrid</td>
<td>Pinnacle</td>
<td>C-Stem</td>
<td>32</td>
<td>Ceramic on ceramic</td>
<td>120</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Cemented</td>
<td>Ogee</td>
<td>C-Stem</td>
<td>32</td>
<td>Metal on polyethylene</td>
<td>144</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Cemented</td>
<td>Ogee</td>
<td>C-Stem</td>
<td>22</td>
<td>Metal on polyethylene</td>
<td>133</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>Cemented</td>
<td>Ogee</td>
<td>Charnley</td>
<td>22</td>
<td>Metal on polyethylene</td>
<td>108</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Cemented</td>
<td>Ogee</td>
<td>Charnley</td>
<td>22</td>
<td>Metal on polyethylene</td>
<td>84</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*All products are manufactured by DePuy, Leeds, United Kingdom.*

### Table 3

**Postoperative Complications**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Complication</th>
<th>Time to Complication Diagnosis, mo</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Anterior subluxation</td>
<td>13</td>
<td>Acetabular revision surgery</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Posterior dislocation</td>
<td>36</td>
<td>Closed reduction-abduction brace</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
More frequently, degenerative disease seems to arise in the nonparalytic extremity, and cross-sectional loads seem to be greatly augmented as a result of overuse to compensate for the contralateral limb. Secondary osteoarthritis also may occur in dysplastic hips with flaccid paralysis that are affected by polio. Nonetheless, only a few reports have described short- and medium-term outcomes of unconstrained THA in limbs affected by poliomyelitis. Because instability can be a potential complication over time, despite well-positioned prosthetic components, this study attempted to determine the long-term effects of unconstrained THA for the treatment of symptomatic hip osteoarthritis in the paralytic limb of patients with asymmetric polio.

Historically, hip arthrodesis was performed sporadically in young patients for painful dislocation, regardless of potential lumbar spine degeneration. Alternative treatments that had been proposed to prevent or treat osteoarthritis in poliomyelitic hips with no degenerative changes or only slight changes. Lau et al reported good results with femoral and pelvic osteotomy to treat femoral head subluxation in 39 young patients with polio at an average 9-year follow-up. These authors concluded that restoration of the femoroacetabular anatomy is crucial to counterbalance muscular atony. Lee et al reviewed their experience with periacetabular osteotomy to stabilize both nonparalytic and paralytic postpolio hips of young adults and reported substantial improvement in muscle strength and acetabulum head quotient as well as normalization of the center-edge angle. However, longer follow-up is necessary to make categorical conclusions about the progression of osteoarthritis as these patients age and muscular imbalances remain.

Although it is difficult to draw general conclusions with only 6 patients, this study showed acceptable long-term clinical outcomes, with a marked decrease in VAS pain score after THA in the ipsilateral hip of patients with muscle strength of at least M3 motor power of hip abductors. Similarly, pain and knee scores showed improvement after total knee arthroplasty in poliomyelitic limbs with at least antigravity quadriceps strength, with worse outcomes reported in patients with less than antigravity quadriceps strength and postpolio myelitis syndrome or severe preoperative knee hyperextension. Yoon et al also reported improvement in mHHS and VAS pain score after cementless THA in patients with ipsilateral poliomyelitis, even though only a few patients were pain-free at last follow-up. Giori and Lewallen suggested that postpolio syndrome may explain some residual trivial pain, as reported in the current series.

Patients with decreased muscular tone seem to be at risk for dislocation. Although some authors recommend constrained acetabular components, the use of unconstrained cups has been accepted because constrained cups may be associated with loosening and failure of the locking liner ring if the mechanical demands that lead to impingement and instability persist over time, as in these cases. The current study reported 2 of 6 patients with instability, but 1 was an isolated case treated with closed reduction without recurrence. Although this is speculative, this isolated episode may be expected in patients who have a paralytic limb in which muscular tone may decrease dramatically over time as a result of misuse, as seen in postpolio syndrome. The patient who required a revision had a vertical cup as a result of a technical inaccuracy that was diagnosed after the first arthroplasty, a complication that can be expected in patients with severe dysplasia. Although the current study was small, the dislocation rate appears to be similar to previously reported rates with polio and comparable to the rate of developmental dysplasia of the hip. In agreement with the literature, the current findings suggest that unconstrained THA is a viable option in poliomyelitis. Although this is speculative, the use of large-diameter ceramic heads on ultra-high-molecular-weight polyethylene liners with a posterior rim may help to prevent dislocation in future patients with muscular atony.

No further surgical complications occurred in the current series. As previously noted, when treating these patients, aseptic loosening and wear do not seem to be major issues in unconstrained arthroplasty. Conversely, these complications are theoretically more predictable in constrained THA because the acetabular component-bone interface is exposed to considerably more stress. Berend et al described a long-term failure rate of 42.1%
after analyzing 755 cases of constrained THA at a minimum 10-year follow-up. To the authors’ knowledge, only 1 report27 suggested the use of constrained THA in patients with polio. However, osteolysis and loosening are major concerns in patients who have diminished bone quality at the acetabular cancellous bone as a result of dysplasia or disuse. Although they analyzed a small cohort, Yoon et al13 described neither aseptic loosening nor infection at an average 7-year follow-up. A systematic review of the literature on 42 THA procedures in similar patients (with Down syndrome) with dysplastic hips and decreased muscular tone reported a survival rate of 81% to 100% at a mean follow-up of 105 months, with good clinical results and pain relief.32

**Limitations**

The current study had several limitations. First, its retrospective nature correlated with the biases exclusive to the study design. Despite studying a consecutive series of patients, the series was small and did not include a control group of similar patients (eg, those with myelomeningocele or Down syndrome) to compare outcomes. Second, clinical outcomes were associated with only 2 scores (mHHS and VAS pain score) that were used at the time the first cases were treated. A more detailed statistical analysis of other scores, such as the Western Ontario and McMaster Universities Osteoarthritis Index, Hip Outcome Score, and Nonarthritic Hip Score, could increase the significance of the authors’ findings. Third, unlike previous reports, the authors did not consider leg length discrepancy as an outcome because some preoperative and postoperative radiographs were not digitalized and a measuring bias may have existed. Although it is speculative, the authors believe that preserving limb imbalance is a major outcome in patients with polio because leg length may affect joint reaction forces and tension along the abductor system.5 However, this study is 1 of the largest series of patients with residual poliomyelitis treated with unconstrained THA, which is still controversial, and it helps to illustrate long-term outcomes, with specific attention to instability.

**Conclusion**

Unconstrained inserts appear to be a viable option for treating secondary hip osteoarthritis in the affected limb of patients with polio, despite a higher risk of later instability. Although a dislocation ratio of one-third is high, constrained liners in young patients (eg, those with polio) are not without complications. The findings of the current study suggest that component orientation is crucial to achieve good long-term outcomes.

**References**

23. Gruen TA, McNeice GM, Amstutz HC.


