Total Hip Arthroplasty After Lower Extremity Amputation

Derek F. Amanatullah, MD, PhD; Robert T. Trousdale, MD; Rafael J. Sierra, MD

There are approximately 1.6 million lower extremity amputees in the United States. Lower extremity amputees are subject to increased physical demands proportional to their level of amputation. Lower extremity amputees have a 6-fold higher risk of developing radiographic osteoarthritis in the ipsilateral hip and a 2-fold risk of developing radiographic osteoarthritis in contralateral hip when compared with the non-amputee population. Additionally, there is a 3-fold increased risk of developing radiographic osteoarthritis in the ipsilateral hip after an above knee amputation when compared with a below knee amputation. The authors retrospectively reviewed 35 total hip arthroplasties after lower extremity amputation. The mean clinical follow-up was 5.3±4.0 years. The mean time from lower extremity amputation to total hip arthroplasty was 12.2±12.8 years after a contralateral amputation and 5.4±6.0 years after an ipsilateral amputation (P=.050). The mean time to total hip arthroplasty was 15.6±15.4 years after an above knee amputation and 6.4±6.1 years after a below knee amputation (P=.021). There was a statistically significant improvement in the mean Harris Hip Score from 35.9±21.8 to 76.8±12.8 with total hip arthroplasty after a contralateral amputation (P<.001). There also was a statistically significant improvement in the mean Harris Hip Score from 25.4±21.7 to 78.6±17.1 with total hip arthroplasty after an ipsilateral amputation (P<.001). Three (17.7%) total hip arthroplasties after a contralateral amputation and 2 (11.1%) total hip arthroplasties after an ipsilateral amputation required revision total hip arthroplasty. Patients with an ipsilateral amputation or a below knee amputation progress to total hip arthroplasty faster than those with a contralateral amputation or an above knee amputation, respectively. Lower extremity amputees experience clinically significant improvements with total hip arthroplasty after lower extremity amputation. [Orthopedics. 2015; 38(5):e394-e400.]

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In the United States, approximately 1.6 million individuals have had a lower extremity amputation, and 30,000 to 40,000 lower extremity amputations are performed annually. Most lower extremity amputations are performed for complications of peripheral vascular disease, diabetes mellitus, or both. Lower extremity trauma, musculoskeletal tumors, infection or sepsis, and congenital etiologies account for the remainder of lower extremity amputations.

Lower extremity amputees are subject to increased physical demands. The level of lower extremity amputation is directly proportional to the increase in oxygen consumption required for ambulation. Retrospective studies found a wide range, from 5% to 61%, of either the ipsilateral or contralateral hip osteoarthritis after a lower extremity amputation. Kulkarni et al retrospectively evaluated 44 lower extremity amputees and found that 24 (55%) of the ipsilateral hips and 8 (18%) of the contralateral hips had osteoarthritis. This was 6-fold higher for the ipsilateral hip and 2-fold higher for the contralateral hip when compared with the non-amputee population. In addition, a 3-fold increased risk of ipsilateral hip osteoarthritis occurred after an above knee amputation (AKA) compared with a below knee amputation (BKA). Compensation by the hip flexors, extensors, and external rotators for the lack of ankle function during gait has been speculated as a cause of increased ipsilateral hip degeneration. Below knee amputation protects the ipsilateral knee and predisposes the contralateral knee to radiographic osteoarthritis. However, amputation, especially an AKA, provides no such protection for the ipsilateral hip.

The clinical and patient-reported outcomes of total hip arthroplasty (THA) in the amputee population are poorly described in the literature. Only 29 cases have been published about THA after an ipsilateral lower extremity amputation, with varied follow-up, reporting of clinical outcomes, and complications. In addition, no published case reports or clinical data exist regarding the performance of THA after a contralateral lower extremity amputation. The authors present the first retrospective series of THA after contralateral lower extremity amputation and the largest retrospective series of THA after ipsilateral lower extremity amputation.

**Materials and Methods**

A retrospective review identified a consecutive set of primary THAs from the authors’ institution between 1981 and 2009. Patients with a minimum of 2-years follow-up after THA were identified with the use of a total joint registry that has prospectively followed all patients who have undergone a total joint arthroplasty at the authors’ institution since 1969. The registry includes patient demographics, date of last evaluation, implants, reoperation, and type of complication. Patients are scheduled for regular clinical evaluations at 1, 2, and 5 years following THA and every 5 years thereafter. The institutional review board reviewed and approved this study prior to initiation.

Patients were included in the study if they had a THA completed in the time period stated above, as well as a lower extremity amputation prior to THA. The primary endpoint measured was failure, which was defined as revision for any reason. Thirty-five THAs were performed by 17 surgeons in 34 patients after lower extremity amputation. Seventeen (48.6%) THAs were performed on the contralateral side of the amputation and 18 (51.4%) on the ipsilateral side. Mean patient age, height, weight, body mass index (BMI) (Table 1), and underlying diagnoses for lower extremity amputation (Table 2), as well as average operative time, surgical approach, and femoral head size (Table 3), were recorded. The postoperative and most recent radiographs of all hips were reviewed for implant migration or subsidence, loosing of the acetabular component according to DeLee and Charnley and the femoral component according to Gruen et al and wear according to Stilling et al. The operative reports and clinical notes were reviewed to correlate clinical findings. Functional status was evaluated both pre- and postoperatively, Pre- and postoperative Harris Hip Scores (HHS) were calculated from clinical examinations and patient surveys. Complications were recorded from the clinical and operative record.

All continuous values are reported as the mean, and errors are reported as SD where applicable. All categorical values are reported as number and percent when applicable. Comparisons of patient-reported outcomes were performed using a t test, Fisher exact test, or chi-square analysis, as appropriate. Statistical significance was set at a P value less than .05.

### Table 1

<table>
<thead>
<tr>
<th>Demographic</th>
<th>ContraLateral THA</th>
<th>Ipsilateral THA</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at THA, mean±SD, y</td>
<td>58.3±16.2</td>
<td>63.0±15.8</td>
<td>.391</td>
</tr>
<tr>
<td>Male:female, No.</td>
<td>12:5</td>
<td>13:5</td>
<td>1.000</td>
</tr>
<tr>
<td>Height, mean±SD, cm</td>
<td>171.5±10.3</td>
<td>171.6±12.7</td>
<td>.989</td>
</tr>
<tr>
<td>Weight, mean±SD, kg</td>
<td>87.9±27.0</td>
<td>81.4±27.4</td>
<td>.524</td>
</tr>
<tr>
<td>BMI, mean±SD, kg/m²</td>
<td>29.9±7.4</td>
<td>27.4±7.9</td>
<td>.388</td>
</tr>
</tbody>
</table>

**Abbreviations:** BMI, body mass index; THA, total hip arthroplasty.
A total of 26,957 primary THAs with a minimum of 2 years of follow-up were performed at the authors’ institution from 1981 to 2009. Total hip arthroplasty after a contralateral amputation represents 0.063% of all THAs, whereas THA after an ipsilateral amputation represents 0.067% of all THAs.

Follow-up
Mean clinical follow-up for all patients was 5.3±4.0 years and mean radiographic follow-up was 4.1±4.1 years. Mean clinical follow-up for THA after a contralateral lower extremity amputation was 5.7±4.6 years and mean radiographic follow-up was 4.9±4.9 years. Mean clinical follow-up for THA after an ipsilateral lower extremity amputation was 4.9±3.5 years and mean radiographic follow-up was 3.3±3.1 years. No statistically significant difference was observed in the clinical or radiographic follow-up for THA after a contralateral or an ipsilateral lower extremity amputation (P=.596 and .252, respectively). Seven (41.2%) patients died after a contralateral lower extremity amputations: 5 less than 10 years after THA and 2 more than 10 years after THA. Ten (55.6%) patients died less than 10 years after THA after an ipsilateral lower extremity amputation. No statistically significant difference was found in the mortality rate of THA after a contralateral or an ipsilateral amputation (P=.330).

No acetabular migration was observed at final follow-up after THA with an ipsilateral or a contralateral lower extremity amputation. At final follow-up, 3 (8.6%) cemented THAs had less than 1 mm subsidence (2 [11.1%] after an ipsilateral and 1 [5.9%] after a contralateral lower extremity amputation). Radiolucent lines were visible at final follow-up in 2 (11.1%). Total hip arthroplasties after an ipsilateral lower extremity amputation in acetabular zones I and III. At final follow-up, no radiolucent lines were seen around the acetabulum in THAs after a contralateral lower extremity amputation. Radiolucent lines in the cement–bone interface of the femur were visible at final follow-up in 3 THAs after a contralateral lower extremity amputation: 1 in zone 1, one in zone 3, one in zone 6, and 4 in zone 7. Radiolucent lines in the cement–bone interface of the femur were visible at final follow-up in 6 (17.1%) THAs after an ipsilateral lower extremity amputation: 1 in zone 1, one in zone 2, two in zone 3, one in zone 5, one in zone 6, and 2 in zone 7. At final follow-up, 4 (11.4%) acetabular liners demonstrated less than 1 mm of wear after THA with an ipsilateral or a contralateral lower extremity amputation. At final follow-up, 2 (11.8%) acetabular liners had more than 1 mm of wear after THA with a contralateral lower extremity amputation.
ity: a Trilogy liner with a 28-mm Zirconia femoral head (3 mm; Zimmer, Warsaw, Indiana) and a Reflection liner with a 32-mm Oxinium head (4 mm; Smith & Nephew, Memphis, Tennessee). No statistical correlation could be made between any radiographic finding and HHS or mode of revision THA at final follow-up.

Time to THA After Amputation
Mean time from amputation to THA was 12.2±12.8 years after a contralateral lower extremity amputation. Eight (47.1%) THAs were performed contralateral to a BKA, 2 (11.8%) were performed contralateral to a through knee amputation, and 7 (41.2%) were performed contralateral to an AKA (Table 4).

Mean time from amputation to THA was 5.4±6.0 years after an ipsilateral lower extremity amputation. Fourteen (77.8%) THAs were performed ipsilateral to a BKA, 2 (11%) were performed ipsilateral to a through knee amputation, and 2 (11.1%) were performed ipsilateral to an AKA (Table 4). Mean time to THA after an ipsilateral lower extremity amputation was statistically shorter than the mean time to THA after a contralateral lower extremity amputation (P=.050).

Mean time to THA for either hip was 15.6±15.4 years after an AKA and 6.4±6.1 years after a BKA. Mean time to THA for either hip after a BKA was statistically shorter than the mean time to THA for either hip after an AKA (P=.021).

Functional Status
Pre- and postoperative HHS were calculated from clinical examinations and patient surveys. For THA after a contralateral lower extremity amputation, mean preoperative HHS was 35.9±21.8 (range, 7 to 77) and mean postoperative HHS was 76.8±12.8 (range, 58 to 100). For THAs after an ipsilateral lower extremity amputation, mean preoperative HHS was 25.4±21.7 (range, 5 to 77) and mean postoperative HHS was 78.6±17.1 (range, 53 to 100). A statistically significant improvement was observed in HHS with THAs after a contralateral and an ipsilateral lower extremity amputation (40.9 and 53.2, respectively; both P<.001).

Revision and Complications
Five (29.4%) major postoperative complications were observed with THA after a contralateral lower extremity amputation. Two (11.8%) patients had dislocations, 2 (11.8%) had periprosthetic fractures, and 1 (5.9%) had a deep periprosthetic infection at final follow-up. One dislocation was treated closed without recurrent instability, whereas the other dislocation had a concomitant deep periprosthetic infection requiring component resection. One fracture was a Vancouver C periprosthetic fracture requiring open reduction and internal fixation, whereas the other 2 fractures were Vancouver B2 periprosthetic fractures requiring revision THA. Three (17.7%) revision THAs occurred after contralateral lower extremity amputation.

Four (22.2%) major postoperative complications occurred with THA after an ipsilateral lower extremity amputation. One (5.6%) patient had a dislocation, 2 (11.1%) had periprosthetic fractures, and 1 (5.6%) had aseptic loosening of the components at final follow-up. The dislocation was treated closed without recurrent instability. One fracture was a Vancouver C periprosthetic fracture requiring open reduction and internal fixation, whereas the other fracture was a Vancouver B2 periprosthetic fracture requiring revision THA. The patient with aseptic loosening required revision THA. Two (11.1%) revision THAs occurred after ipsilateral lower extremity amputation.

No patient in either group developed a superficial infection, sterile hematoma requiring reoperation, deep venous thrombosis, pulmonary embolism, nerve palsy, or other documented complication.

DISCUSSION
Total hip arthroplasty after an ipsilateral or a contralateral lower extremity amputation is rare, occurring in 0.067% and 0.063% of all THAs, respectively. Mean time of progression to THA after a contralateral lower extremity amputation was 12.2 years. This was more than double the time of progression (average, 5.4 years) to THA after an ipsilateral lower extremity amputation. These observations in time of progression are supported by the distribution and prevalence of hip osteoarthritis in the amputee population.5,6 Mean time of progression to THA after an AKA was 15.6 years. This was more than double the time of progression (mean, 6.4 years) to THA after a BKA. This seems contradictory to the observation of Kulkarni et al.5 They reported a 3-fold increased risk of ipsilateral hip osteoarthritis after an AKA when compared with a BKA.5 The lower metabolic demand for ambulation of a

Table 4

<table>
<thead>
<tr>
<th>Amputation Level</th>
<th>Contralateral THA</th>
<th>Ipsilateral THA</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemipelvectomy</td>
<td>1 (5.9)</td>
<td>0 (0.0)</td>
<td>.271</td>
</tr>
<tr>
<td>Transfemoral</td>
<td>6 (35.3)</td>
<td>2 (11.1)</td>
<td></td>
</tr>
<tr>
<td>Knee disarticulation</td>
<td>2 (11.8)</td>
<td>2 (11.1)</td>
<td></td>
</tr>
<tr>
<td>Transtibial</td>
<td>8 (47.1)</td>
<td>13 (72.2)</td>
<td></td>
</tr>
<tr>
<td>Ankle disarticulation</td>
<td>0 (0.0)</td>
<td>1 (5.6)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: THA, total hip arthroplasty.
BKA likely contributes to more symptomatic hip osteoarthritis and earlier THA.²,³

No known case reports evaluate the clinical or functional performance of THA after a contralateral lower extremity amputation. Mean HHS improved from 35.9 to 76.8 after THA in contralateral lower extremity amputees (P < .001). Five (29.4%) major postoperative complications occurred with THA after a contralateral lower extremity amputation. Radiolucent lines at the femoral bone–cement interface were visible at final follow-up in 3 (18%) cemented THAs after a contralateral lower extremity amputation. These are the most common zones for acetabular lucency in the non-amputee population as well.²¹ Radiolucent lines at the femoral bone–cement interface were visible at final follow-up in 6 (33%) cemented THAs after an ipsilateral lower extremity amputation. This is higher than the presence of lucent lines after cemented THA in the non-amputee population (3%).²² Three (17.7%) revision THAs occurred after a contralateral lower extremity amputation.

There are 29 case reports and small case series that suggest clinical and functional improvement with THA after an ipsilateral lower extremity amputation.⁸⁻¹⁷ In the current series, mean HHS improved from 25.4 to 78.6 after THA in ipsilateral lower extremity amputees (P < .001). Four (22.2%) major postoperative complications occurred with THA after an ipsilateral lower extremity amputation. Radiolucent lines were visible in acetabular zones I and III with THAs after an ipsilateral lower extremity amputation, but these are the most common zones for acetabular lucency in the non-amputee population as well.²¹ Radiolucent lines at the femoral bone–cement interface were visible at final follow-up in 6 (33%) cemented THAs after an ipsilateral lower extremity amputation. This is higher than the presence of lucent lines after cemented THA in the non-amputee population (3%) and THAs after a contralateral lower extremity amputation (18%).²² Non-progressive isolated radiolucent lines at the bone–cement interface do not cause late aseptic loosening or failure.²²,²⁴ Two (11.1%) revision THAs occurred after an ipsilateral lower extremity amputation.

Of the 9 (25.7%) major complications among all THAs in lower extremity amputees, 5 (55.5%) were periprosthetic fractures. Two were Vancouver C periprosthetic fractures that required open reduction and internal fixation, and the other 3 were Vancouver B2 periprosthetic fractures requiring revision THA. Measurement of bone mineral density in lower extremity amputees demonstrates T-scores less than -2 in the ipsilateral femoral neck.⁵ Eighty-eight percent of lower extremity amputees have radiographic evidence of osteoporosis in the ipsilateral limb after BKA.² Patients with an ipsilateral AKA have lower bone mineral densities than those with an ipsilateral BKA (Figure).³ This has been directly linked to higher metabolic demand for ambulation of an AKA.²,³

In addition, individuals with lower extremity amputations have difficulty standing with one leg in front of the other, turning 360°, and placing the alternate foot on a stool.²⁵ When induced to fall, individuals with lower extremity amputations demonstrate spatial and temporal differences when recovering with their prosthetic limb.²⁶ The inherent deficit in coordination while standing or performing simple activities, the increased metabolic cost of ambulation, and ipsilateral limb osteoporosis associated with a lower extremity amputation likely predispose lower extremity amputees to periprosthetic fractures that ultimately require open reduction internal fixation or revision THA.

Surgical preparation, hip dislocation, component positioning, and rehabilitation are serious surgical issues in lower extremity amputees, especially after an AKA, due to the altered anatomy and leverage at the time of surgery. The residual limb may be enclosed in an exoprosthesis for long durations and may have irregularities in wound healing. The skin of the residual limb deserves additional attention during preparation and isolation with an impervious drape.¹³ Of the 35 THAs in the current series performed after lower extremity amputation, only 1 (2.9%) had

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Figure: Anterior to posterior radiograph of a right hip after an ipsilateral below knee amputation for failed fusion of a Charcot ankle with osteopenia of the proximal femur (A). Anterior to posterior radiograph after proximally coated total hip arthroplasty (B).
a deep infection. Preoperative planning should include the entire residual limb. Osteoporosis, flaring of the distal canal, and thinning of the distal cortex may influence the choice of implant or type of fixation (ie, cementation).27

In the setting of an AKA, the knee and leg are not present as a lever arm for hip dislocation. In this setting, a bone clamp on the proximal femoral diaphysis proximal to the insertion of the gluteus maximus tendon or a medial to lateral Steinmann pin can be used for traction and orientation.11,15 If the hip is not able to be dislocated with these aids, in situ osteotomy of the femoral neck or trochanteric osteotomy may be required.8 Other useful anatomic landmarks include the lesser trochanter and proximal projection of the linea aspera. However, malposition of the femoral component is possible even in the setting of a BKA, hence establishing a reference point prior to dislocation is preferred.10 Intraoperative tenotomies and postoperative rehabilitation should be used to treat hip and knee flexion contractures in the setting of THA and an ipsilateral lower extremity amputation.9,12,28

Retrospectively analyzed data have several limitations, including the fidelity of the record, loss to follow-up, and selection bias. The current authors have used a systematic approach to patient selection and a high fidelity electronic medical record in an attempt to minimize any of these inadvertent biases. Total hip arthroplasty was performed by 17 orthopedic surgeons, all of whom were fellowship-trained in total joint arthroplasty but each of whom used a different approach to the THA itself. In addition, the HHS has not been validated in amputees and may not be the best outcome measure in a patient population with numerous physical and mental reasons for pain, limping, ambulatory aids, limited ambulation, and decreased range of motion. This would diminish the ability to detect a pre- and postoperative difference in the challenging patient population in the current study.

**CONCLUSION**

Total hip arthroplasty after lower extremity amputation is rare. The ipsilateral hip progresses to osteoarthritis at a faster rate than the contralateral hip after lower extremity amputation. Total hip arthroplasty after lower extremity amputation provides excellent functional and clinical outcomes, whether on the ipsilateral or contralateral extremity, as long as the challenges of THA in the amputated extremity are acknowledged.

**REFERENCES**

24. Iwaki H, Scott G, Freeman MA. The natural


