The Effect of Total Hip Arthroplasty on the Sciatic Nerve: an Electrodiagnostic Evidence Study

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Objective: Objectively evaluate the incidence of sciatic nerve injury after a total hip arthroplasty (THA) performed through a posterolateral approach.

Methods: Patients scheduled to undergo THA were evaluated preoperatively and postoperatively with electrophysiologic studies, the Western Ontario and McMaster Universities Osteoarthritis index (WOMAC) questionnaire and other methods described in the study. Patients older than 21 years with any of the following preoperative diagnoses: primary or secondary osteoarthritis, aseptic avascular necrosis, rheumatoid arthritis, and posttraumatic arthritis were included. Variables used for analysis were sex, age, and body mass index (BMI). The Mann–Whitney U and Wilcoxon tests and, Pearson and Spearman correlation statistics were used for analysis of categorical and continuous data respectively.

Results: Electrodiagnostic data showed alterations in 17 patients (70.8%). No signs of sciatic nerve injury. The mean preoperative and postoperative WOMAC scores were 40 and 74, respectively (p = 0.0001). Statistical differences were noted in sural sensory amplitude (SSA) and distal amplitude of the tibialis motor nerve in the female group (p=0.007; p=0.036, respectively). The SSA also demonstrated differences in the obese group (p=0.008). In terms of age, both the SSA (Pearson p=0.010 and Spearman p=0.024) and the proximal latency of the peroneal motor nerve (Pearson p=0.026 and Spearman p=0.046) demonstrated a decrease in amplitude and an increase in latency that was inversely related with age.

Conclusion: According to our subclinical electrophysiological findings, surgeons that use the posterolateral approach in THA procedures must be conscious of the sciatic nerve's vulnerability to reduce possible clinical complications. [*P R Health Sci J 2020;39:254-259*]

Key words: Total hip arthroplasty, Posterolateral approach to the hip, Sciatic nerve injury

Osteoarthritis is the primary cause of hip pain in the adult population. Osteoarthritis-associated joint pain was a debilitating force for those members of the population suffering from osteoarthritis until the advent of total hip arthroplasty (THA) in 1969. This procedure has allowed, and continues to allow, the reestablishment of mobility and functionality in a significant proportion of those individuals in the United States (US) population who suffer from advanced osteoarthritis. Total hip arthroplasty is an effective surgical intervention for the relief of pain, increase of function, and improvement of quality of life, while also providing a relatively economical solution. As the US population ages, the demand for this procedure is increasing and is expected to grow exponentially in the next decades. Kurtz et al. noted a 50% increase in the prevalence of THA from 1990 to 2002 (1), while they projected an increase in incidence of over 150%, rising from 208,600 in 2005 to approximately 572,000 by 2030 (2).

In a study done by Schmalzried et al. (3), the clinical incidence of nerve palsy after a THA ranged from 0.6 to 3.7%; in this study, sciatic nerve injury was present in more than 80% of the cases. When the posterior approach to the hip is performed, the sciatic nerve is the most commonly affected nerve. The nerve exits the

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pelvis via the greater sciatic foramen below the piriformis muscle and diverges into the common peroneal nerve and the tibial nerve at the level of the upper angle of the popliteal fossa. Due to the anatomic location, the peroneal division tends to suffer greater damage compared to the tibial division, especially with long and excessive traction (4,5). In contrast, the incidences of other types of nerve injuries, such as femoral nerve palsy after a THA, have been reported to range from 0.1 to 0.4%, while obturator nerve palsy has been described in individual case reports, only (6,7).

In general, the incidence of nerve damage after a THA is around 1 to 2%. This percentage varies according to the main indication for the procedure. For example, current knowledge shows that in patients who undergo surgery due to hip dysplasia, the incidence ranges from 3 to 8% (3). In a study using electromyography (EMG), preoperatively and postoperatively, 70% of the patients who underwent a THA suffered subclinical damage to the sciatic nerve (8). Nerve irritation can induce electrical signal changes, such as decreases in amplitude or increases in latency in nerve action potential transmission. Although electromyographic studies indicate that nerve injury may occur in up to 70% of cases (8), damage to the sciatic nerve due to a THA and the correlation of that damage to clinical symptoms have not been properly addressed in the literature. Therefore, the purpose of this study was to evaluate the incidence of sciatic nerve injury during a THA (using the posterolateral approach to the hip) through the pre- and postoperative measurement of electrophysiological changes in the sciatic nerve. Some of the factors that can cause neuropathy after a THA include revision arthroplasty, direct trauma, tension applied during retraction, tension due to limb lengthening (more than 4 cm) (9), ischemia, congenital dislocation (10), surgery duration, and intrapelvic extrusion of cement (5,7). In previous studies, sciatic nerve palsy has been found to occur mainly during the use of the posterior approach, compared to other approaches used for THA (11–14).

Patients and Methods

This was a prospective study in which we performed electrodiagnostic (EDX) testing on patients undergoing THA. Demographic data collected during the study included age, sex, and body mass index (BMI). The inclusion criteria included those patients from 21 to 90 years of age who had been diagnosed with congenital hip dysplasia, aseptic avascular necrosis, or rheumatoid arthritis, as well as those who suffered from traumatic or nontraumatic osteoarthritis. The exclusion criteria consisted of patients outside of the previously mentioned age range, patients who had had a previous surgical procedure performed on the affected hip, patients who had undergone a revision surgery on the affected hip, and patients who had suffered previous damage or paralysis to the sciatic nerve. The study was approved by the Institutional Review Board of the University of Puerto Rico, Medical Sciences Campus. All the patients had to sign an informed consent in order to participate in the study.

All the surgeries were performed by a single, fellowship-trained, adult reconstruction orthopedic surgeon using the posterolateral approach to the hip and took place at 3 different institutions (San Juan City Hospital, the Oncologic Hospital of Puerto Rico, and the Dr. Ramon Rodriguez Arnau University Hospital). The EDX studies were conducted at the Department of Physical and Rehabilitation Medicine of the University of Puerto Rico, Medical Sciences Campus, by a single physical medicine and rehabilitation specialist. The following variables were evaluated: compound muscle action potential, sensory nerve action potential, late-response F waves and signs of denervation on an EMG test (positive sharp waves, fibrillation potentials; see the Electrophysiological Assessment in the Patients and methods section). The EDX studies were conducted preoperatively and 21 days postoperatively.

During the preoperative and 2-month postoperative evaluations, the patients were given the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) questionnaire in order to assess pain (when present), rigidity (when present), and physical function level related to osteoarthritis of the knee and hip. It has also been used with joint arthroplasty surgical populations. The questionnaire consists of 24 questions: 5 related to pain, 2 to stiffness, and 17 to physical function. It can be used to monitor the course of the disease or to determine the effectiveness of a variety of interventions (pharmacologic, surgical, physiotherapeutic, etc.). It provides an excellent look at a patient's functional capacity and complements the more objective data provided by magnetic resonance imaging, arthroscopy, cartilage biopsy, and radiographs. The questionnaire is available in 5-point Likert, 100 mm visual analog scale, and 11-point numerical rating formats. When using the WOMAC questionnaire, each question's response is assigned a score of 0 (extreme) to 4 (none). The individual question scores are then summed to form a raw score ranging from 0 (worst) to 96 (best). Finally, the raw scores are normalized by multiplying each one by 100/96. This produces a WOMAC score of from 0 (worst) to 100 (best). For our study, the time it took to administer the questionnaire was 10 to 15 minutes, and the time it took to score it was 5 to 10 minutes. This tool allowed us to characterize the progression of symptoms during the months after the surgery in order to determine the improvement or the worsening of symptoms. All the EDX and questionnaire data were used to determine any pattern that might arise in relation to nerve damage. The time allotted to the full evaluation of each patient was approximately 60 minutes.

Total Hip Arthroplasty procedure – Posterolateral approach to the hip

The sciatic nerve is predisposed it to damage during a THA using a posterolateral approach since the muscle groups and posterior portion of the acetabulum and femur associated with the normal anatomic course of the nerve are directly manipulated during the procedure. The posterior approach described by Moore (1957), which is also known as the "Southern" approach, was used in all the patients, by the same surgeon, in accordance with the surgeon's usual practice.

Consistent with the protocol for this approach, every patient was placed in a lateral position on the operating table. The incision length was directly proportional to the patient's body weight and musculature and may have fluctuated from 8 cm to 14 cm. The tensor fascia lata and gluteus maximus fascia were divided in line with the initial skin incision. The fibers of the gluteus maximus were then separated bluntly. The trochanteric bursa was excised to gain exposure to the short external rotators. This group of muscles, along with the piriformis, were detached from the hip capsule and tagged with sutures for identification and repair at the end of the procedure. This exposed the posterior hip capsule which was incised in either a T-shape or semilunar fashion and tagged. The hip was then dislocated posteriorly using internal rotation, flexion, and adduction. With the aid of pins and sutures, a length measurement was performed, at this point. A neck cut was performed, according to the template, using a blunt Cobra retractor and a femoral elevator for adequate exposure. The force required while using the femoral elevator was inversely proportional to the time involved in the femoral preparation. A difficult exposure required incision to the gluteus maximus insertion. The Femur was sequentially reamed and broached until cortical fit was obtained.

The exposure of the acetabulum was achieved with a Hohmann-like anterior acetabular retractor with a superior pin fixed in the ilium and another in the Hibbs posterior retractor. The next step was sequential reaming, with special care taken to avoid contact with the posterior soft-tissue envelope. The final acetabular component was impacted in place, with, on occasion, supplemental screw fixation. The trial reduction was performed with particular attention paid to obtaining stability in all the planes and acceptable leg-length measurements. The final femoral component was impacted in conjunction with the femoral head. Hip capsule and short rotators closure were performed. Insertion of the needle for the repair was always performed at the posterior entry point, to avoid being too close to the sciatic nerve; Ethibond 5 sutures were used to make the repair. The rest of the wound-closure process was performed in layers.

Clinical assessment

Neuropathies were diagnosed whenever a patient had a sensory or motor deficit in the extremity in which the THA was performed and that deficit had not been recorded or presented, preoperatively. During each surgery, total preoperative time, blood loss, and changes in limb-length were recorded.

Electrophysiological assessment

The nerves were examined using the criteria and values established by the American Association of Neuromuscular & Electrodiagnostic Medicine (15). Nerves were stimulated using supramaximal levels along multiple sites throughout the sciatic nerve. Nerve conduction studies were performed to analyze the motor unit action potentials at the extensor digitorum brevis muscle for the peroneal nerve and at the abductor hallucis muscle for the tibial nerve. Signal amplitudes, latencies, and conduction velocities were obtained. The conduction velocity was determined by measuring the distance between the site of the stimulation and the site of the recording and dividing this distance by the latency of response. Sensory components of the nerves were collected for the sural nerve and superficial peroneal nerve. Sensory nerve action potentials were recorded for each component. Late-response F waves for the tibial nerve were recorded. EMG studies were performed using concentric needles at different points, such as the tibialis anterior muscle, peroneus longus muscle, gastrocnemius muscle, and short head of the biceps femoris muscle. Rest and insertional activity were evaluated first, followed by a description of the recruitment patterns and motor unit action potentials. A diagnosis of denervation was made when positive sharp waves and fibrillation potentials in 4 quadrants of muscles (at least 1 cm apart) were detected.

Statistical methods

For the statistical analysis, we considered the influence of age, sex, and BMI in all the data subsets evaluated in the study. When comparing categorically, the Mann–Whitney U and Wilcoxon tests were used. Pearson and Spearman correlation statistics were used to compare continuous data.

Results

During our study, 31 patients fulfilled the inclusion criteria, 16 males (51.6%) and 15 females (48.4%). Seven patients (22.5%; 4 males and 3 females) abandoned the study after the first intervention; 4 of them due to poor tolerance to the electrophysiologic study and 3 due to their having limited resources in terms of transportation to follow-up visits. The remaining 24 patients, 12 males (50%), and 12 females (50%), completed the study. The mean age was 51.34 (range: 26.0–79.0) and the mean BMI was 31.65 (range: 20.40–47.42). The most common preoperative diagnosis was osteoarthritis (58%; Table 1).

Table 1. Preoperative diagnosis (N = 24)

Diagnosis	Number of patients (%)
Avascular Necrosis	7 (30%)
Rheumatoid Arthritis	2 (8%)
Posttraumatic Arthritis	1 (4%)
Osteoarthritis	14 (58%)

Clinical assessment

The estimated average blood loss during surgery was 259 ml (100 to 700 ml). The average surgery time was 89 min (50 to 160 min). The average change in limb length was 2.1 cm (0.78

to 3.0 cm). No statistical difference was found when the results were stratified for limb lengthening, blood loss, and surgery time.

No new motor or sensory neurological deficits were identified after a THA. The mean preoperative WOMAC score for the 24 patients was 74 (range: 46 to 92), and the mean postoperative WOMAC score was 40 (range: 11 to 75), which was statistically significant ($p = 0.0001$). When each of the elements of the WOMAC questionnaire (i.e. stiffness, pain, and physical function) was evaluated, the average preoperative and postoperative values were statistically different ($p < 0.05$). Therefore, the averages were different for each of the sections as well as for the entire questionnaire, demonstrating correspondence among them (Table 2). There were no statistical differences on either section of the questionnaire when stratifying by age, sex, or BMI.

Table 2. WOMAC individual components results

WOMAC components (N = 24)	Preoperative Mean	Postoperative Mean	p
Overall	74	40	0.0001
Stiffness	6.13	3.35	0.001
Physical function	50.42	28.20	0.001
Pain	14.38	8.15	0.0001

Electrophysiological assessment

Upon comparing the preoperative and postoperative results (Table 3), we found that 17 patients (70.8%) had experienced electrophysiologic changes in 1 or more nerves. No previous studies have found there to be any clinical changes in terms of nerve injury that can be linked to BMI (16). The same studies demonstrated a direct correlation in delays in the recovery from nerve palsy and BMI. Since our data sample was small, we categorized patients into 2 groups (based on their BMIs): non-obese (BMI<29) and obese (BMI ≥ 30).

There were no statistical differences in the non-stratified preoperative and postoperative data. No statistical difference was found, postoperatively, in the tibialis motor amplitude proximal (TMAP; $p = 0.54$) and the sural sensory amplitude (SSA; $p = 0.56$) in the members of the obese group. There were statistical differences ($p < 0.05$) in the means of the raw data, preoperatively and postoperatively.

Table 3. Distribution of patients who developed abnormal postoperative electrophysiological nerve parameters

Electrophysiological changes in patients	Frequency	Percentage (%) (N = 24)
Decrease in the amplitude of the peroneal motor nerve	2	8.33
Decrease in peroneal motor nerve conduction velocity	3	12.5
Decrease in tibial motor nerve amplitude	4	16.66
Decrease in tibial motor nerve conduction velocity	5	20.83
Prolongation of superficial peroneal nerve onset/peak latency	8	33.33
Total of number of patients who experienced some type of electrophysiological change	17	70.83

When evaluating the influence of age, there were statistical differences in the means of the SSA (Pearson, $p = 0.010$ and Spearman, $p = 0.024$) and peroneal motor latency proximal (PMLP: Pearson, $p = 0.026$; Spearman, $p = 0.046$), revealing a decrease in amplitude and an increase in latency, respectively. When evaluating the influence of sex, in the female group there were statistical differences in the means of the SSA ($p = 0.007$) and the tibial motor amplitude distal (TMAD) ($p = 0.036$) components, revealing a decrease in amplitude, postoperatively. When evaluating the influence of BMI, there was a statistical difference in the means of the SSA ($p = 0.008$) in the obese group, revealing a decrease in amplitude (Table 4).

Complications

None of the patients reported any clinical acute neurological deficits after the procedure. However, one patient suffered a posterior dislocation of the femoral component. The patient's hip was reduced successfully at the emergency department within 4 hours after the dislocation. The patient reported mild discomfort in the first 2 weeks after the dislocation. Concerning all the patients, however, no neuropathies were reported, and the patients successfully returned to their usual activities within 3 weeks. No recurrent dislocations were reported.

Discussion

Hip arthroplasty has been associated with sciatic nerve palsy (17). Recent data have shown that the rate of nerve injury with innovative THA techniques is from 1.7 to 2.1% (18,19). The overall incidence of nerve damage is greater in females in whom the lateral approach has been used (4). Previous studies have shown that, among the traditional surgical approaches used, the posterior approach is associated with a clinical incidence of neuropathy as high as 8% (10, 20, 11–14). In our study and comparing preoperative to postoperative values (described in Table 4), 17 patients (70%) were found to have electrophysiological alterations. Some of these changes were minimal, since the 17 subjects had borderline low parameters at baseline. Since no statistical differences were found in the non-stratified preoperative and postoperative data, no electrophysiological (via nerve conduction studies or EMG) pattern of injury was found after this surgical approach. These findings are comparable with what was reported by Weale et al. (21).

When we stratified for BMI, we found that obese patients were more likely to experience decreases in their SSAs. Previous studies have found no correlation between sciatic nerve injury and an increased BMI. They did find an inverse correlation in regard to nerve recovery and BMI (16). These findings are possibly associated with the tibial component of the injury to the sciatic

Table 4. Difference in Means after stratification (N = 24)

Differences in Means	t		
	Sex	BMI	Age Pearson & Spearman
SPL2 – SPPL1	0.305	0.659	0.818 & 0.341
SPA2 – SPA1	0.597	0.456	0.709 & 0.663
SSPL2 – SSPL1	0.662	0.681	0.793 & 0.547
SSA2 – SSA1	0.007	0.008	0.010 & 0.024
PMLDPro2 – PMLD1	0.413	0.897	0.224 & 0.182
PMLP2 – PMLP1	0.210	0.332	0.026 & 0.046
PMAD2 – PMAD1	0.913	0.219	0.181 & 0.191
PMAP2 – PMAP1	0.514	0.070	0.96 &0.111
PMV2 – PMV1	0.424	0.845	0.210 & 0.795
FWTM2 – FWTM1	0.375	0.148	0.386 &0.546
TMLD2 – TMLD1	0.549	0.497	0.802 & 0.973
TMLP2 – TMLP1	0.567	0.477	0.832 & 0.814
TMAD2 – TMAD1	0.036	0.897	0.907 & 0.723
TMAP2 – TMAP1	0.264	0.722	0.852 & 0.556
TMV2 – TMV1	0.870	0.121	0.627 & 0.474

Variables: SPL: superficial peroneal nerve latency; SPA: superficial peroneal nerve amplitude; SSPL: sensory superficial peroneal nerve latency; SSA: sural sensory amplitude; PMLD: distal latency of peroneal motor nerve ; PMLP: Proximal latency of peroneal motor nerve ; PMAD: distal amplitude of peroneal motor nerve ; PMAP: proximal amplitude of peroneal motor nerve; PMV: peroneal motor nerve velocity; FWTM: F waves tibial motor nerve; TMLD: distal latency of tibial motor nerve; TMLP: proximal latency of tibial motor nerve; TMAD: distal amplitude of tibial motor nerve; TMAP: proximal amplitude of tibial motor nerve; TMV: tibial motor nerve velocity. 1 = preoperative. 2 = postoperative

nerve, with subsequent axonal involvement. After stratifying for sex, we found that females were more at risk of developing the tibial component of the sciatic nerve injury, as evidenced by the statistical differences in the means of the SSA ($p = 0.007$) and the TMAD ($p = 0.036$). Age was also found to have an influence on nerve electrophysiology. We found that there was a direct correlation between the age of the patient and the risk of developing subclinical neuropathies, specifically in terms of the SSA and PMLP components.

Weber et al. noted that clinical examination alone, often led to underestimation of nerve injury (in terms of both degree and incidence) after hip arthroplasty (8); according to our data the clinical and electrophysiological findings were similar when stratification was not performed. In contrast, after the stratification, we found that age, sex, and BMI influenced patient outcomes in some areas. The reduced or underestimation of nerve injury incidence that we found may be due to the development of new and less traumatic surgical techniques and the increasing expertise of surgeons who perform THA. This incidence may also be underreported in the literature since nerve damage is evaluated only when clinical complications are present.

Previous studies have indicated that THA increased quality of life, improved function, and produced great satisfaction, in the majority of cases (this, when the WOMAC hip score was used for evaluation) (22). Our results are consistent with those of the reported literature, in which statistically significant improvements in all 3 categories (stiffness, physical function, and pain) have been demonstrated.

Nerve injury can vary from being silent to symptomatic, and it can induce transient to irreversible damage secondary to the mechanical disruption of axons within the endoneural sheath (23). The criteria used to diagnose nerve injury are the presence of electrophysiological changes in conduction studies and signs of acute denervation, such as fibrillation and positive sharp waves on EMG (24). Nerve injury has been correlated with the high pressures experienced by the sciatic nerve and that occur during acetabular exposure, which is required for reaming and cup placement in total hip resurfacing (25). The posterolateral approach to the hip is a more natural surgical approach compared to other approaches. Less traction is required to gain access to the hip in order to perform the hip arthroplasty; this implies that there will be a reduced operating time and less blood loss.

In our study, no patients reported new clinical neurological deficits during the period of the study. Only 1 patient suffered a complication, a postoperative hip dislocation; the patient underwent close reduction under sedation at the emergency department. No neurological deficits were reported by the patient.

Previous studies of nerve evaluations have indicated that the involvement of the sciatic nerve was greater in the peroneal division than the tibial division when nerve damage occurred, with an estimated incidence of 80% (17). An isolated injury to the tibial division is uncommon. When an injury to the peroneal or sciatic nerve occurs, it mostly takes place proximally, at the level of the arthroplasty (9). In our study, none of the patient evaluations revealed any clinical findings of damage pertinent to either sciatic nerve division.

Some of the limitations in our study were the small number of patients and the loss at follow-up at the beginning of the study, which may have had an effect on the statistical significance of the results. Additionally, our study population did not include revisions, congenital hip dislocations, or hip dysplasia, all of which have been associated with nerve injury. Larger studies including the whole spectrum of surgical approaches and other surgeons' data are needed to confirm these electrophysiological and clinical findings.

In conclusion, the posterolateral approach to the hip in THA is safe and a good therapeutic option for hip pathology. The rate of presentation and incidence of clinical neuropathies is very low, independent of the preoperative diagnosis. The use of EDX studies is an efficient way to evaluate for subclinical neurologic injury. Our study findings correlate to those of previous reports in which subclinical nerve damage existed that might mainly have been caused by operative trauma. The long-term recovery from nerve damage is good unless complete nerve destruction occurs. The intraoperative assessment of nerve function with appropriate monitors might aid in minimizing neurological findings and lead to improved functional outcomes (26,27). On the other hand, the low risks associated with the procedure can make this intervention more expensive, since more resources will be needed to complete the procedure. The findings of a subclinical electrophysiologic study would, in all likelihood, increase the surgical team's awareness of the vulnerability of the sciatic nerve with this approach and advocate for a detailed surgical technique to avoid overt clinical issues.

Resumen

Objetivo: Evaluar la incidencia de lesión del nervio ciático luego de una artroplastia total de cadera (THA, por sus siglas en inglés) con abordaje posterolateral. Métodos: Pacientes programados para THA fueron evaluados con electrofisiología y el índice de osteoartritis de las Universidades Western Ontario y McMaster (WOMAC, por sus siglas en inglés) entre otros. Se incluyeron mayores de 21 años con alguno de los siguientes diagnósticos preoperatorios: osteoartritis primaria o secundaria, necrosis avascular aséptica, artritis reumatoide y artritis postraumática. Las variables analizadas fueron: sexo, edad e índice de masa corporal. Variables continuas se analizaron con la prueba de la U de Mann-Whitney y la prueba de Wilcoxon mientras que variables categóricas se analizaron utilizando las pruebas de Pearson y Spearman. Resultados: 17 pacientes mostraron alteraciones electrofisiológicas (70.8%). La puntuación promedio del WOMAC preoperatoria y postoperatoriamente fueron 40 y 74, respectivamente (p= 0.0001). El grupo femenino mostró diferencias estadísticas en la amplitud sensorial sural (SSA, por sus siglas en inglés) y en los componentes distales de amplitud del nervio tibial motor (p= 0.007, p= 0.036, respectivamente). La SSA demostró diferencias estadísticas en los pacientes obesos (p=0.008). En términos de edad, tanto la SSA (Pearson p = 0.010 y Spearman p =0.024) como la latencia proximal del nervio peroneo motor (Pearson p =0.026 y Spearman p = 0.046), demostraron disminución en amplitud y aumento en latencia con relación inversa a la edad. Conclusión: Se debe considerar la vulnerabilidad del nervio ciático al realizar una THA mediante abordaje posterolateral para minimizar complicaciones.

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