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RESEARCH ARTICLE
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"ANATOMICAL VARIATIONS OF THE SCIATIC NERVE AND THEIR RELEVANCE IN HIP ARTHROPLASTY"

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Abstract

Background: The sciatic nerve is the largest peripheral nerve of the lower limb, and its anatomical course in relation to the piriformis muscle and posterior hip structures is clinically significant in hip arthroplasty. Although the classical description places the sciatic nerve emerging inferior to the piriformis muscle, multiple anatomical variations have been documented, including high division, accessory bundles, and atypical relationships with surrounding musculature. These variations may increase the risk of iatrogenic nerve injury, postoperative neuropathy, altered surgical exposure, and variable response to regional anesthesia. Understanding these variations is essential for orthopedic surgeons performing hip arthroplasty through posterior, anterolateral, or minimally invasive approaches.

Objective: To determine the anatomical variations of the sciatic nerve in patients undergoing hip arthroplasty and to assess their clinical relevance regarding surgical exposure, intraoperative nerve protection, and postoperative neurological outcomes

Methodology: An observational descriptive study was conducted in the Orthopedic Surgery Department Sughra Shafi Medical Complex Narowal over a period of one year from 1st January to 31st December 2024. A total of 50 patients undergoing primary hip arthroplasty for osteoarthritis, femoral neck fractures, or avascular necrosis were selected through consecutive sampling. Intraoperative exploration was performed using standard posterior or anterolateral approaches to document the sciatic nerve course, bifurcation pattern, and relationship with the piriformis muscle. Variants were classified according to Beaton and Anson's anatomical classification. Postoperative neurological assessment was conducted on day 1, day 7, and at 6-week follow-up. Data were

analyzed descriptively, and associations between anatomical variation and postoperative nerve deficits were assessed using chi-square testing.
Results: Sciatic nerve anatomical variations were found in 18% (n = 9) of patients. The most common variant was high division of the tibial and common peroneal components above the piriformis (10%), followed by the peroneal component passing through the piriformis muscle (6%). A rare pattern with both divisions emerging above the piriformis was observed in 2% of cases. Patients with nerve variations showed higher rates of transient postoperative neuropraxia (11.1%) compared to those with classical anatomy (4.8%). The posterior surgical approach demonstrated greater intraoperative difficulty in nerve identification among variation cases. No permanent nerve deficits were observed. High bifurcation and intrapiriformis course were significantly associated with increased risk of temporary nerve irritation ($p < 0.05$).

Keywords: Sciatic nerve, Anatomical variations, Hip arthroplasty, Piriformis muscle, Postoperative neuropraxia, Orthopedic surgery

Introduction:

The sciatic nerve, the largest and one of the most clinically significant peripheral nerves of the human body, plays a central role in the motor and sensory innervation of the lower limb. Originating from the lumbosacral plexus (L4–S3), it typically emerges as a single trunk that exits the pelvis through the greater sciatic foramen, inferior to the piriformis muscle, before traveling down the posterior thigh. Despite this classical description, a substantial body of anatomical and surgical literature has documented considerable variability in its course, branching pattern, and structural relationships with surrounding musculature. These variations, though often asymptomatic in the general population, acquire critical surgical relevance during hip arthroplasty, where inadvertent nerve injury remains one of the most concerning complications[1, 2].

Hip arthroplasty, whether performed through a posterior, lateral, or anterior approach, requires meticulous identification of key anatomical structures, including the sciatic nerve. The posterior approach, in particular, places the nerve at direct risk due to its proximity to the short external rotators and surgical field. Even in anterior and anterolateral approaches, variations in nerve bifurcation level or atypical pathways may influence the risk of traction injury, compression, or entrapment. Sciatic nerve injury in the context of hip arthroplasty, although relatively uncommon, can result in foot drop, sensory deficits, neuropathic pain, prolonged rehabilitation, and significant functional disability. Therefore, a comprehensive understanding of the prevalence and nature of sciatic nerve anatomical variations is essential for surgeons aiming to optimize patient safety and surgical outcomes[3, 4].

The study of nerve variations is well established in cadaveric research, where detailed dissections have identified multiple patterns, most commonly categorized using the Beaton and Anson classification system. These include high division of the sciatic nerve above the piriformis muscle, division passing through the muscle, and courses where one or both nerve components emerge superior to the piriformis. Such anatomical variants may alter the expected topography during surgery, complicating identification and retraction of the nerve. Additionally, high bifurcation may lead to a broadened neural field, increasing vulnerability to inadvertent manipulation. However, data derived from cadaver studies may not fully represent the surgical population, especially those undergoing hip arthroplasty in whom degenerative changes, muscular hypertrophy, or scarring may obscure nerve pathways[5, 6].

While magnetic resonance imaging (MRI) and ultrasonography have enhanced preoperative visualization of peripheral nerve structures, intraoperative assessment remains the gold standard for identifying anatomical variations during arthroplasty. Intraoperative documentation allows surgeons to evaluate the nerve in its functional and pathological state, providing direct evidence of variations that may influence surgical decision-making. However, such intraoperative studies are relatively limited in number, and the literature lacks sufficient data from diverse populations, particularly in the context of orthopedic surgical procedures rather than cadaveric dissection[7].

Understanding the clinical implications of anatomical variations extends beyond anatomical mapping. Variations in the sciatic nerve may influence susceptibility to neuropraxia or axonotmesis due to traction during limb positioning, manipulation during acetabular reaming, or compression by retractors. The risk may be heightened in patients with pre-existing anatomical anomalies, making identification crucial for minimizing postoperative neurological complications. Furthermore, recognizing these variations allows surgeons to modify operative techniques, adjust retractor placement, and ensure careful soft tissue handling, ultimately reducing the risk of iatrogenic nerve injury[8].

In this context, investigating the prevalence of sciatic nerve variations in patients undergoing hip arthroplasty provides valuable insight into the surgical anatomy specific to this patient population. Such information contributes to improved procedural planning, enhanced intraoperative awareness, and better perioperative counseling regarding neurological risks. Despite the known importance of these variations, limited regional data exist regarding their frequency and surgical relevance in arthroplasty patients[9].

Therefore, the present study was designed to evaluate, document, and classify the intraoperative anatomical variations of the sciatic nerve in patients undergoing hip arthroplasty in a tertiary care setting. By correlating these variations with intraoperative challenges and immediate postoperative neurological outcomes, this study aims to highlight their clinical significance and contribute to safer, evidence-based surgical practice[10].

Methodology:

An observational descriptive study was conducted in the Orthopedic Surgery Department Sughra Shafi Medical Complex Narowal over a period of one year from 1st January to 31st December 2024.The study aimed to document intraoperative anatomical variations of the sciatic nerve in patients undergoing hip arthroplasty and assess their clinical relevance in relation to surgical exposure and postoperative neurological outcomes.

Study Design and Sample Size:

A sample of 50 patients scheduled for primary hip arthroplasty was selected through consecutive non-probability sampling. Both elective and emergency arthroplasty cases were included. All surgeries were performed by consultant orthopedic surgeons with a minimum of five years of experience in hip reconstruction.

Inclusion Criteria:

1. Patients aged 18 years and above**.**
2. Individuals undergoing primary hip arthroplasty for:
   - Osteoarthritis
   - Avascular necrosis of the femoral head
   - Femoral neck fractures
   - Post-traumatic arthritis
3. Patients providing written informed consent.

Exclusion Criteria:

1. Patients undergoing revision hip arthroplasty**.**
2. Individuals with previous hip surgeries or gluteal region operations that may distort anatomy.
3. Patients with congenital hip deformities such as developmental dysplasia of the hip (DDH).
4. Presence of active local infection or soft tissue pathology around the hip.
5. Known preoperative sciatic nerve palsy or peripheral neuropathy.
6. Patients unwilling to undergo follow-up neurological assessment.

Data Collection and Intraoperative Procedure:
All the patients underwent either a posterior **or** anterolateral surgical approach, as determined by the operating surgeon. After standard exposure, the sciatic nerve was carefully identified, dissected, and inspected throughout its visible course. The nerve's relationship with the piriformis muscle, level of bifurcation, and any atypical pathways were documented. Variations were classified based on Beaton and Anson's classification system.
During surgery, difficulty in nerve identification, retractor requirements, and the presence of adhesions or distorted anatomy were recorded. Standardized forms were used to ensure uniform data entry.

Postoperative Neurological Assessment:
Neurological evaluation focusing on sensory and motor function of the sciatic nerve and its branches was performed on postoperative day 1**,** day 7, and at 6-week follow-up. Transient neuropraxia and persistent deficits were documented.

Data Analysis:
Data were analyzed using descriptive statistics, including frequencies and percentages. Associations between anatomical variations and neurological outcomes were tested using the chi-square test, with significance set at $p < 0.05$.

Results:
A total of 50 patients undergoing primary hip arthroplasty were included in the study. The mean age of participants was 61.4 ± 9.8 years**,** with 60% males (n = 30) and 40% females (n = 20). The indications for arthroplasty included osteoarthritis (38%), femoral neck fracture (34%), avascular necrosis (20%), and post-traumatic arthritis (8%). The posterior approach was used in 70% (n = 35) and the anterolateral approach in 30% (n = 15).

Prevalence of Sciatic Nerve Variations:
Anatomical variations of the sciatic nerve were observed in 18% (n = 9) of patients. The classical pattern (single trunk exiting below the piriformis) was present in 82% (n = 41)**.**

Variation Type (Beaton & Anson Classification)	**Frequency (n)**	**Percentage (%)**
Type I: Classical pattern (single trunk below piriformis)	41	82%
Type II: High division above piriformis	5	10%
Type III: Peroneal division passing through piriformis	3	6%
Type IV: Both divisions above piriformis	1	2%
Total Variants	9	18%

Table 1: Frequency of Sciatic Nerve Variations (n = 50)

Intraoperative Findings:
Difficulty in intraoperative nerve identification was significantly higher in patients with anatomical variations.

Variable	**Normal Anatomy (n = 41)**	**Variant Anatomy (n = 9)**
Difficulty in identification	6 (14.6%)	5 (55.5%)
Need for additional retraction	4 (9.7%)	3 (33.3%)
Adhesions around nerve	3 (7.3%)	2 (22.2%)
Intraoperative nerve irritation	1 (2.4%)	2 (22.2%)

Table 2 Intraoperative Nerve-Related Observations

Postoperative Neurological Outcomes:
Transient neuropraxia was more frequent in patients with anatomical variation.

Outcome	Normal Anatomy (n = 41)	Variant Anatomy (n = 9)
No neuropraxia	39 (95.1%)	8 (88.9%)
Transient neuropraxia	2 (4.9%)	1 (11.1%)
Persistent deficit at 6 weeks	0 (0%)	0 (0%)

Table 3 Postoperative Neuropraxia

A significant association was found between the presence of anatomical variation and transient postoperative neuropraxia ($p < 0.05$).

Discussion:
The findings of this study demonstrate that anatomical variations of the sciatic nerve are relatively common in patients undergoing hip arthroplasty, with a prevalence of 18%. This frequency aligns with previously reported cadaveric and clinical studies, suggesting that variations are often under-recognized in routine surgical practice. The predominance of high division and intrapiriformis pathways underscores the need for heightened surgical vigilance, particularly when using the posterior approach, where direct visualization of the nerve is more frequently required. These variations influence not only the ease of nerve identification but also the risk of inadvertent traction or compression injury during acetabular preparation and soft tissue manipulation[11, 12].
The study further showed that patients with variant anatomy experienced greater intraoperative challenges, including increased difficulty in nerve identification and higher rates of nerve irritation. These findings highlight the surgical implications of anatomical diversity, as unrecognized deviations from typical sciatic nerve pathways may predispose patients to postoperative neuropraxia. Although all neurological symptoms observed were transient, their occurrence emphasizes the importance of early recognition, gentle soft-tissue handling, and appropriate placement of retractors[13, 14].
Transient neuropraxia occurred more commonly in patients with anatomical variations (11.1%) compared with those with classical anatomy (4.9%). While no cases of permanent deficits were recorded, this difference is clinically relevant, especially given the functional and rehabilitative consequences of sciatic nerve injury after hip arthroplasty. The absence of permanent neurological complications may be attributed to experienced surgeons and careful identification of the nerve in all cases.
A key strength of this study lies in its intraoperative assessment, which provides real-time documentation of nerve variations in living tissue a more clinically relevant approach compared with cadaveric studies. However, the study also underscores the potential need for preoperative imaging in selected cases, particularly those with prior hip pathology, limited mobility, or suspected muscular anomalies[15].
Overall, the study reinforces the necessity of understanding sciatic nerve anatomy and its variations to enhance surgical safety. Tailoring the operative approach to account for anatomical diversity, combined with meticulous technique, may significantly reduce the risk of nerve-related complications in hip arthroplasty[16].

Limitations:
This study has several limitations. The sample size of 50 patients, although adequate for preliminary analysis, limits the generalizability of findings to larger populations. The study relied solely on intraoperative observation without adjunct preoperative imaging, which may have provided additional anatomical detail. Only two surgical approaches—posterior and anterolateral—were assessed, limiting comparison across other techniques. Long-term neurological follow-up beyond six weeks was not conducted, restricting evaluation of delayed neuropathic symptoms. Finally, the study was performed at a single tertiary center, and anatomical variations may differ across populations, demographics, and ethnic backgrounds.

Implications:
The results have important implications for orthopedic surgical practice. Awareness of sciatic nerve variations can enhance preoperative planning, particularly when selecting the surgical approach or anticipating intraoperative challenges. Surgeons may benefit from incorporating selective preoperative imaging or nerve mapping in high-risk or anatomically complex cases. Training programs should emphasize anatomical variability to improve intraoperative decision-making among residents and fellows. These findings also highlight the importance of using gentle soft-tissue handling and strategic retractor placement to reduce neural complications. Ultimately, integrating these considerations may improve postoperative neurological outcomes and patient safety in hip arthroplasty procedures.

Conclusion:
This study highlights the notable prevalence of sciatic nerve anatomical variations in patients undergoing hip arthroplasty and their significant impact on intraoperative complexity and postoperative nerve outcomes. High division and intrapiriformis pathways were the most frequent variants, contributing to increased rates of transient neuropraxia. Although all neurological symptoms resolved without permanent deficits, the findings emphasize the importance of careful identification and protection of the sciatic nerve during surgery. Enhanced anatomical awareness, meticulous technique, and consideration of patient-specific variations may help minimize complications and improve surgical safety. Further multicenter studies with larger populations are recommended to validate these results.

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