Anatomical Variation of The Sciatic Nerve in Relation to the Piriformis Muscle
Cadaveric Study in Sudanese Among Selected Medical Schools At Khartoum State - Sudan From July to October

A dissertation Submitted for partial Fulfillment of the Requirement for the Degree of M.sc in Clinical Anatomy

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الآية

بسم الله الرحمن الرحيم

قال تعالى (سِنْرِيْهِمْ آيَاتِنَا فِي الْْفَاقِ وَفِي أَنفُسِهِمْ حَتَّى يَتَبَيَّنَ نَهُمْ
أَنَّهُ انْحَكُّ أَوَ نَمْ يَكْفِ بِرَبِّكَ أَنَّهُ عَهَى كُمِّ شَيْءٍ شَهِيدٍ)

صدق الله العظيم

سورة فصلت - الآية - (53)
Dedication

To my parents
To my brothers and sisters
To all those stood beside me and helped me to come to this level
which is honor and blessing to me
I dedicate this work.
Acknowledgements

First of all, thanks for Allah forgive me health and willing to conduct this research. All thanks to prof. John Girgis (my supervisor) for spending the time and energy for supervision. And special thanks to all staff of Alneelain University, specially prof. Mustafa Elnimeiri who taught me the course of research methodology. Great thanks to staff of the Department of Human Anatomy of Alneelain University, Khartoum University, Al-Zaiem Al-Azhari University, Bahry University, Sudan International University, Ahfad University for Women, Omdurman Islamic University, National Ribat University, International University of Africa, University of Medical Science and Technology, and Alwattania University.

Finally, my thanks to my family (my mother, my brothers, and my sisters) for their unlimited support. So, their support is well appreciated.
List of Abbreviations

ASIS: Anterior superior iliac spine.

CPN: Common Peroneal Nerve.

IP: Infrapiriform portion of the Greater Sciatic Foramen.

PM: Piriformis Muscle.

SN: Sciatic Nerve.

SP: Suprapiriform portion of the Greater Sciatic Foramen.

TN: Tibial Nerve.
Abstract

The Sciatic nerve is the largest nerve in the body formed by the sacral plexus L4-S3 in the pelvis. It emerges through the greater sciatic foramen below the piriformis muscle and enters the gluteal region. It may divide into its common peroneal and tibial nerve components within the pelvis and its relationship with the piriformis muscle is variable. Such variations between the sciatic nerve and the piriformis muscle may cause nerve compression, resulting in non-discogenic sciatica (or piriformis syndrome). The aim of this study was to describe and analyze sciatic nerve variation in relation to the piriformis muscle among the Sudanese people in Khartoum state. The study included 60 cadavers of which twelve specimens showed variations.
ملخص الأطروحة

يعتبر العصب الوركي أكبر عصب في الجسم ينشأ من الضفيرة العجزية داخل الحوض يغادر العصب الحوض خلال الفتحة الوركية العظمى تحت العضلة الكمثرية ليدخل المنطقة الألوية.

قد ينقسم العصب الوركي إلى العصب الشظي العام والعصب الظنبوبى داخل الحوض مع وجود اختلافات في علاقته مع العضلة الكمثرية. هذه الاختلافات بين العصب الوركي والعضلة الكمثرية قد يسبب انضغاط العصب الوركي أو أحد فروعه، مما يؤدي إلى ما يعرف بعرق النساء (أو متلازمة الكمثرية).

هـدف هذه الدراسة وصف وتحليل العصب الوركي واختلافاته في علاقته بالعضلة الكمثرية بين السودانيين في ولاية الخرطوم. اعتمدت الدراسة على ستون عينة من مختلف المشارح بكليات الطب حيث أظهرت اثنتي عشر عينة منها اختلافًا عن العلاقة الطبيعية بين العصب الوركي والعضلة الكمثرية.
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Figure (3): The common fibular nerve (CFN) passing through the Piriformis muscle (PM) and the tibial nerve (TN) passing through the infrapiriform portion of the greater sciatic foramen in the right gluteal region (unilateral).

Figure (4): A photograph showing the divided piriformis muscle and the dividing sciatic nerve passing between the two portions of the piriformis muscle (bilateral).
CHAPTER ONE

INTRODUCTION
1.1 Introduction

"There are many variations observed while dissecting human bodies in the dissection room of the medical school. These variation may in involve all tissueof the body such as bones, muscles,vessls and nerves. Variation are principally due to the variable genetic composition , which is an inheritance carried over from an ancestral origin. Most of the anatomical variations are benign. According to Galen and Vesalis, anatomical variations are the results of an imperfect or unnatural development "(1).

The aim of this study is to observe the variation of the sciatic nerve and also the piriformis muscle and record their percentage among Sudanese people,either by dissecting specimen or looking in to specimens already dissected.

"The sciatic nerve is one of the important nerves, it innervates the posterior thigh muscles,all leg ,and foot muscles,and the skin of most of the leg and the foot.It also gives articular branches to all joints of the lower limb.These muscles perform important functions such as supporting the body weight,locomotion,the ability to move from one place to another and maintain balance". (2)

Sciatic nerve is a thickest nerve in the human body.It is formed in the lesser pelvis by ventral division of L4 to s3. It leaves the pelvis and enters the gluteal region through the greater sciatic foramen, below the piriformis muscle. It runs in the posterior aspect of the thigh. Then at the superior angle of the popliteal fossa it divides into tibial and common peroneal nerves.

"There may be numerous variations in the course ,division and distribution of the nerve. The variations in relationship between the
sciatic nerve and the piriformis muscle are common and are clinically significant. Sometimes it divides in to terminal branches at high level while still in the pelvis, then it exit in different ways. Accordingly the relation between the nerve and the piriformis muscle is classified into different types I, II, III, and IV\(^{(3)}\).

"Knowledge of the prevalence of the piriformis and the sciatic nerve anomalies is important for many clinical situations. These anomalies are relevant to clinicians performing procedures such as imaging guided injections of the piriformis muscle, total hip arthroplasty and piriformistenotomy for piriformis syndrome\(^{(4)}\).

1.2 Justification:

Although the variations of the sciatic nerve in relation to the piriformis muscle are common there are no enough studies of this topic among the Sudanese people. Also there are many clinical problems associated with the variations or anomalies of the sciatic nerve and the piriformis muscle.

The awareness of these variations plays an important role for surgeons, anaesthetists and clinicians during various procedures and diagnosing various clinical conditions.
1.3 Objectives:

General Objective:

The aim of this study is to see the anatomical variations of the sciatic nerve in relation to the piriformis muscle in Sudanese cadaveric among selected medical schools in Khartoum state.

Specific Objectives:

* To evaluate the characteristics of the sciatic nerve and its relationship to the piriformis muscle in group of Sudanese people.

* To define the level of the sciatic nerve exit and division.

* To make the best use of existing evidence to estimate the frequencies of clinical feature in patients reported to have piriformis syndrome.

* To analyze the anatomical and measurement relationship between the piriformis muscle and the sciatic nerve in order to contribute towards better clinical understanding of the gluteal region.
CHAPTER TWO
LITERATURE REVIEW
2. Literature Review

Anatomy of the Sciatic Nerve

Unique features of the Sciatic nerve

"The sciatic (ischiadic) nerve (SN) is the largest one in humans. This depends not only on the number of gathered nerve fibers, but also on the large region supplied by the nerve. The importance of the nerve in the learning process of human morphology for medical students depends on several unique feature of the nerve.

Firstly, the sciatic nerve is a structure which is easy to recognize, prepare, separate and observe. The width of the nerve can exceed 2cm and its thickness reaches 0.5cm.

Secondly, the physiological and clinical role of the nerve is easy to describe and explain, even to students who are starting their medical educational process.

Thirdly, the sciatic nerve presents significant variability concerning its topography and division into terminal branches (common fibular nerve and tibial nerve). This macroscopic, individual variation is easily noticeable by medical students, even during standard classes of normal anatomy. In fact it is one of the most evident examples and is very suitable as an illustration of the phenomenon of individual variation concerning human body construction. The sciatic nerve consists mostly of lumbosacral fibres originating from L4-L5 and S1-S3 spinal segments. They are both motor and sensory. The motor branches of the nerve supply the posterior group of thigh muscles as well as joints of the lower limb. Its sensory branches supply the whole leg and foot areas with the exception of the anteromedial region of the leg and the medial margin of the foot." 

(5)
The Tibial Nerve (TN):

"The large of the two terminal branches of the sciatic, arises from the anterior branches of the fourth and fifth lumbar and first, second, and third sacral nerves. It descends along the back of the thigh and through the middle of the popliteal fossa, to the lower part of the popliteus muscle, where it passes with the popliteal artery beneath the arch of the soleus. It then runs along the back of the leg with the posterior tibial vessels to the interval between the medial malleolus and the heel, where it divides into the medial and lateral plantar nerves. In the thigh it is overlapped by the hamstring muscles above, and then becomes more superficial, and lies lateral to, and some distance from, the popliteal vessels; opposite the knee-joint, it is in close relation with these vessels, and crosses to the medial side of the artery. In the leg it is covered in the upper part of its course by the muscles of the calf; lower down by the skin, the superficial and deep fasciae and placed on the deep muscles, and lies at first, at the medial side of the posterior tibial artery, but soon crosses that vessel and descends on its lateral side as far as the ankle. In the lower third of the leg it runs parallel to the medial margin of the tendo calcaneus. The branches of this nerve are: articular, muscular, medial sural cutaneous, medial calcaneal, medial and lateral plantar.

Articular branches are usually three in number and supply the knee-joint; two of these accompany the superior and inferior medial genicular arteries; and the third is the middle genicular artery. Just above the bifurcation of the nerve an articular branch is given off to the ankle-joint.

Muscular branches are four or five in number, arise from the nerve as it lies between the two heads of the Gastrocnemius muscle; they supply that muscle, the plantaris, soleus, and Popliteus ones. The branch for the
Popliteus turns around the lower border and is distributed to the deep surface of the muscle. Lower down, muscular branches arise separately or by a common trunk and supply the Soleus, Tibialis posterior, Flexor digitorum longus, and Flexor hallucis muscles. The branch to the last muscle accompanies the peroneal artery while that to the Soleus enters the deep surface of the muscle.

The medial sural cutaneous nerve descends between the two heads of the Gastrocnemius muscle, and about the middle of the back of the leg, pierces the deep fascia, and unites with the anastomotic ramus of the common peroneal to form the sural nerve.

The sural nerve is formed by the union of the medial sural cutaneous with the peroneal anastomotic branch, passes downward near the lateral margin of the tendo calcaneus, lying close to the small saphenous vein, to the interval between the lateral malleolus and the calcaneus. It runs forward below the lateral malleolus, and is continued as the lateral dorsal cutaneous nerve along the lateral side of the foot and little toe, communicating on the dorsum of the foot with the intermediate dorsal cutaneous nerve, a branch of the superficial peroneal nerve. In the leg, its branches communicate with those of the posterior femoral cutaneous ones.

The medial calcaneal branches supply the skin of the heel and medial side of the sole of the foot.

The medial plantar nerve, the larger of the two terminal divisions of the tibial nerve, accompanies the medial plantar artery. From its origin under the laciniate ligament it passes under cover of the Abductor hallucis muscle, and appearing between this muscle and the Flexor digitorum brevis, gives off a proper digital plantar nerve and finally divides
opposite the bases of the metatarsal bones into three common digital plantar nerves. It gives the following branches: The cutaneous branches pierce the plantar aponeurosis between the Abductor hallucis and the Flexor digitorum brevis muscles and are distributed to the skin of the sole of the foot. The muscular branches supply the Abductor hallucis, the Flexor digitorum brevis, the Flexor hallucis brevis, and the first Lumbricalis muscles, those for the Abductor hallucis and Flexor digitorum brevis arise from the trunk of the nerve near its origin and enter the deep surfaces of the muscles; the branch of the Flexor hallucis brevis springs from the proper digital nerve to the medial side of the great toe, and that for the first Lumbricalis from the first common digital nerve. The articular branches supply the articulations of the tarsus and metatarsus. The proper digital nerve of the great toe supplies the Flexor hallucis brevis muscle and the skin on the medial side of the great toe. The three common digital nerves pass between the division of the plantar aponeurosis, and each splits into two proper digital nerves; those of the first common digital nerve supply the adjacent sides of the great and second toes; those of the second, the adjacent sides of the second and third toes; and those of the third, the adjacent sides of the third and fourth toes. The third common digital nerve receives a communicating branch from the lateral plantar nerve; the first gives a twig to the first Lumbricalis. Each proper digital nerve gives off cutaneous and articular filaments; and opposite the last phalanx sends upward a dorsal branch, which supplies the structures around the nail, the continuation of the nerve being distributed to the ball of the toe. It will be observed that these digital nerves are similar in their distribution to those of the median nerve in the hand.
"The Lateral Plantar Nerve supplies the skin of the fifth toe and lateral half of the fourth, as well as most of the deep muscles, its distribution being similar to that of the ulnar nerve in the hand. It passes obliquely forward with the lateral plantar artery to the lateral side of the foot. Lying between the Flexor digitorum brevis and Quadratus plantae and, in the interval between the former muscle and the Abductor digiti quinti, divides into a superficial and a deep branch. Before its division, it supplies the Quadratus plantae and Abductor digiti quinti. The superficial branch splits into a proper and a common digital nerve; the proper digital nerve supplies the lateral side of the little toe, the flexor digiti quinti brevis, and the two interossei of the fourth intermetatarsal space; the common digital nerve communicates with the third common digital branch of the medial plantar nerve and divides into two proper digital nerves which supply the adjoining sides of the fourth and fifth toes. The deep branch accompanies the lateral plantar artery on the deep surface of the tendons of flexor muscles and the Abductor hallucis muscle, and supplies all the interossei muscles (except those in the fourth metatarsal space).

The second, third, and fourth lumbricales, and the Adductor hallucis." (6).

**The Common Peroneal Nerve (CPN):**

"It is about one-half the size of the tibial nerve, it is derived from the dorsal branches of the fourth and fifth lumbar and the first and second sacral nerves. It descends obliquely along the lateral side of the popliteal fossa to the head of fibula, close to the medial margin of the biceps femoris muscle. It lies between the tendon of the Biceps femoris and lateral head of the Gastrocnemius muscles, wind around the neck of the fibula, between the peroneus longus and the bone, and divides beneath
the muscle into the superficial and deep peroneal nerves. Previous to its division, it gives off articular and lateral sural cutaneous nerves.

The articular branches are three in number; two of these accompany the superior and inferior lateral genicular arteries to the knee; the upper one occasionally arises from the trunk of the sciatic nerve. The third (recurrent) articular nerve is given off at the point of division of the common peroneal nerve; it ascends with the anterior recurrent tibial artery through the Tibialis anterior muscle to the front of the knee.

The lateral sural cutaneous nerve supplies the skin on the posterior and lateral surfaces of the leg; one branch, the peroneal anastomotic (n. communicans fibularis), arises near the head of the fibula, crosses the lateral head of the Gastrocnemius muscle to the middle of the leg, and joins the medial sural cutaneous to form the sural nerve. The peroneal anastomotic is occasionally continued down as a separate branch as far as the heel.

The deep peroneal nerve begins at the bifurcation of the common peroneal nerve, between the fibula and upper part of the Peroneus longus muscle, passes obliquely forward beneath the Extensor digitorum longus muscle to the front of the interosseous membrane, and comes into relation with the anterior tibial artery above the middle of the leg; it then descends with the artery to the front of the ankle-joint, where it divides into a lateral and a medial terminal branch. It lies at first on the lateral side of the anterior tibial artery, then in front of it, and again on its lateral side at the ankle-joint. In the leg, the deep peroneal nerve gives muscular branches to the Tibialis anterior, Extensor digitorum longus, Peroneus tertius, and Extensor hallucis propius muscles, and an articular branch to the ankle-joint. The lateral terminal branch passes across the tarsus,
beneath the Extensor digitorum brevis muscle, and is enlarged like the dorsal interosseous nerve at the wrist, supplies the Extensor digitorum brevis muscle. From the enlarge part, three minute interosseous branches are given off, which supply the tarsal joint and the metatarsophalangeal joints of the second, third, and fourth toes. The first of these sends a filament to the second Interosseus dorsalis muscle. The medial terminal branch accompanies the dorsalis pedis artery along the dorsum of the foot, and, at the first interosseous space it divides into two dorsal digital nerves which supply the adjacent sides of the great and second toes, communicating with the medial dorsal cutaneous branch of the superficial peroneal nerve. Before it divides it gives off an interosseous branch at the first space which supplies the metatarsophalangeal joint of the great toe and sends a filament to the first interosseous dorsalis muscle.

The Superficial Peroneal Nerve supplies the Peronei muscles (longus and brevis) and the skin over the greater part of the dorsum of the foot. It passes forward between the Peronei and the Extensor digitorum longus muscle, pierces the deep fascia at the lower third of the leg, and divides into a medial and an intermediate dorsal cutaneous nerve. In its course between the muscle, the nerve gives off muscular branches to the Peronaei longus and brevis, and cutaneous filament to the integument of the lower part of the leg. The medial dorsal cutaneous nerve passes in front of the ankle-joint, and divides into two dorsal digital branches, one of which supplies the medial side of the great toe, the other, the adjacent side of the second and third toes. It also supplies the integument of the medial side of the foot and ankle, and communicates with the saphenous nerve, and with the deep peroneal nerve. The intermediate dorsal cutaneous nerve, the smaller, passes along the lateral part of the dorsum of the foot, and divides into dorsal digital branches, which supply the
contiguous sides of the third and fourth, and of the fourth and fifth toes. It
also supplies the skin of the lateral side of the foot and ankle, and
communicates with the sural nerve The branches of the superficial
peroneal nerve supply the skin of the dorsal surfaces of all the toes
excepting the lateral side of the little toe, and the adjoining sides of the
great and second toes, the former being supplied by the lateral dorsal
cutaneous nerve from the sural nerve, and the latter by the medial branch
of the deep peroneal nerve. Frequently some of the lateral branches of the
superficial peroneal are absent, and their places are then taken by
branches of the sural nerve”

Anatomy of the Piriformis Muscle:

"The piriformis is a flat muscle, pyramidal in shape, lying almost parallel
with the posterior margin of the gluteus medius muscle. It is situated
partly within the pelvis against its posterior wall, and partly at the back of
the hip-joint. It arises from the front of the sacrum by three fleshy
digitations, attached to the portions of the bone between the first, second,
third, and fourth anterior sacral foramina, and to the grooves leading from
the foramina: a few fibers also arise from the margin of the greater sciatic
foramen, and from the anterior surface of the sacrotuberous ligament.

The muscle passes out of the pelvis through the greater sciatic foramen,
the upper part of which it fills, and is inserted by a rounded tendon into
the upper border of the greater trochanter behind, but often partly blended
with, the common tendon of the obturator internus and superior and
inferior gemelli muscles”

Relations; within the pelvis, the anterior surface of piriformis muscle is
related to the rectum (especially on the left), the sacral plexus of the
nerves and branches of the internal iliac vessels, the posterior surface lies against the sacrum. Outside the pelvis, its anterior surface is in contact with the posterior surface of the ischium and capsule of the hip joint and its posterior surface with gluteus maximus muscle. Its upper border is in contact with the gluteus medius muscle and the superior gluteal vessels and nerve, its lower border with coccygeus and gemellus superior muscles. The inferior gluteal and internal pudendal vessels, the sciatic, posterior femoral cutaneous and pudendal nerves and muscular branches from the sacral plexus appear in the buttock in the interval between piriformis and gemellus superior muscles. The relationship between the piriformis and the sciatic nerve is variable. The undivided nerve may emerge above the muscle (usual) or through the muscle. The major divisions of the nerve may lie either at the side of the muscle, or (the most common variant) one division passes between the heads of a divided muscle and another division passes either above or below the muscle.

**Vascular supply:** In the buttock, the piriformis is supplied mainly by the superior gluteal artery, with contributions from the gemellar branches of the internal pudendal artery. There may be a separate branch from the inferior gluteal artery. In the pelvis the main supply is from the lateral sacral artery, with contributions from both gluteal vessels.

**Innervation:** The piriformis is innervated by branches from (L5, S1, and S2).

**Actions:** The piriformis muscle rotates the extended thigh laterally, but abducts the flexed thigh.

**Clinical anatomy:** Clinically it is not possible to test the piriformis alone; however, for suspected injury to the piriformis the best provocative
test is to ask the seated person to abduct the thighs. Buttock pain suggests piriformis injury"(8).

Variation:" In 17% of people, the piriformis muscle is pierced by parts or all of the sciatic nerve. Several variations occur, but the most common type of anomaly(81% of anomalies) is the Beaton's type B which is when the common peroneal nerve pierces the piriformis muscle. It may be united with the gluteus medius muscle, send fibers to the gluteus minimus, or receive fibers from the superior gemellus muscle.Also may have one or two sacral attachments; or it may be inserted into the capsule of the hip joint"(7).

Applied Anatomy

Surface Marking of the Sciatic Nerve:

"The sciatic nerve can be represented by a line which commences at a point mid-way between the postero–superior iliac spine (easily identified as it lies deep to the sacral dimple), and the tip of the ischial tuberosity, curves outwards and downwards just medial to a point midway between the greater trochanter and the ischial tuberosity, and then continues vertically downwards in the midline of the posterior aspect of the thigh" (9).
**Block of the Sciatic Nerve:**

"There are a variety of approaches to the sciatic nerve block. A popular and reliable one is that described originally by Labat - the posterior approach. The patient is kept in the lateral position with the knees flexed; a line is drawn between the greater trochanter and the posterior superior iliac spine. At the mid-point of this line, a perpendicular line is drawn. The entry point of the needle is 4-5 cm along this perpendicular line. The needle will be directed towards the sciatic. If a nerve stimulator is used, movements of the foot will ensue when the needle is in the correct position. Other approaches such as the anterior, lateral and Raj approach are favoured by some, as the patient need not be turned into the lateral position. However, if a lumbar plexus block is to be performed in addition to a sciatic nerve block to provide anaesthesia or analgesia of the whole lower limb, the patient will already be in the ideal position for a Labat sciatic nerve block." (9).

**Injury of the Sciatic Nerve**

"A pain in the buttock may result from compression of the sciatic nerve by the piriformis muscle (piriformis syndrome). Individuals involved in sports that require excessive use of the gluteal muscles (e.g., ice skaters, cyclists, and rock climbers) and women are more likely to develop this syndrome. In approximately 50% of cases, the histories indicate trauma to the buttock associated with hypertrophy and spasm of the piriformis. In the approximately 12% of people in whom the common fibular division of the sciatic nerve passes through the piriformis, this muscle may compress the nerve."
Complete section of the sciatic nerve is uncommon. When this injury occurs, the leg is useless because extension of the hip is impaired, as is flexion of the leg. All ankle and foot movements are also lost. Incomplete section of the sciatic nerve (e.g., from stab wounds) may also involve the inferior gluteal and/or the posterior femoral cutaneous nerves. Recovery from a lesion of the sciatic nerve is slow and usually incomplete.

"With respect to the sciatic nerve, the buttock has a side of safety (its lateral side) and a side of danger (its medial side). Wounds or surgery on the medial side of the buttock may injure the sciatic nerve and its branches to the hamstrings (semitendinosus, semimembranosus, and biceps femoris) on the posterior aspect of the thigh. Paralysis of these muscles results in impairment of thigh extension and leg flexion" (2).

**Intragluteal injections:**

"The gluteal region is a common site for intramuscular injection of drugs. Gluteal intramuscular injections penetrate the skin, fascia, and muscles. The gluteal region is a favorable injection site because the muscles are thick and large; consequently, they provide a substantial volume for absorption of injected substances by intramuscular veins. It is important to be aware of the extent of the gluteal region and the safe region for giving injections. Some people restrict the area of the buttock to the most prominent part. Which may be dangerous because the sciatic nerve lies deep to this area .

Injections into the buttock are safe only in the superolateral quadrant of the buttock or superior to a line extending from the posterior superior iliac spine to the superior border of the greater trochanter (approximating the superior border of the gluteus maximus).
Intramuscular injections can also be given safely into the anterolateral part of the thigh, where the needle enters the tensor fasciae latae as it extends distally from the iliac crest and anterior superior iliac spine. The index finger is placed on the ASIS, and the fingers are spread posteriorly along the iliac crest until the tubercle of the crest is felt by the middle finger.

"An intragluteal injection can be made safely in the triangular area between the fingers (just anterior to the proximal joint of the middle finger) because it is superior to the sciatic nerve. Complications of improper technique include nerve injury, hematoma, and abscess formation"(2).

*Variation of the Sciatic Nerve in Relation to the Piriformis Muscle:*

Standring S(8) reported that the point of division of the sciatic nerve to its major components (tibial and common peroneal) is variable. The common site is at the junction of the middle and lower thirds of the thigh, near the apex of the popliteal fossa. The division may occur at any level above this, though rarely below it. It is not uncommon for the major components to leave the sacral plexus separately, in which case the common peroneal component usually passes through the piriformis muscle at the greater sciatic notch while the tibial component passes below the muscle.

Ellis H et al , (9) mentioned that the SN usually divides into two components at the apex of the popliteal fossa, and its division may occur at any level proximally. Occasionally, the two components are
separated right from their origins from the sacral plexus, in which case the common peroneal nerve usually pierces the piriformis muscle (10% of the cases). Moore KL and Dalley AF\(^{(2)}\) mentioned that CPN passes through the piriformis, and the TN passes through the infrapiriformis portion of greater sciatic foramen (IP) in 12.2% of the specimens, and that CPN passes through the suprapiriformis portion of the greater sciatic foramen (SP), and the TN passes through the IP in 0.5% of the specimens in a study conducted on 650 extremities. Snell RS\(^{(10)}\) said that the CPN occasionally leaves the SN high in the pelvis and appear in the gluteal region by passing above or through the piriformis muscle.

Beaton and Anson classified variations of the piriformis muscle and the sciatic nerve in 120 specimens in 1937, and in 240 specimens in 1938\(^{(11,12)}\). Their classification is known as the Beaton and Anson; the classification being as follows:

Type 1: Undivided nerve below undivided muscle
Type 2: Divisions of the nerve between and below divided muscle
Type 3: Divisions above and below undivided muscle
Type 4: Undivided nerve between heads
Type 5: Divisions between and above heads
Type 6: Undivided nerve above undivided muscle

Beaton and Anson\(^{(11)}\) found type 1, type 2, type 3, and type 4 in (84.2%, 11.7%, 3.3% and 0.8% of the specimens respectively). Beaton\(^{(12)}\) reported that, in twenty-four cases of variation, eight occurred unilaterally. The other sixteen cases were bilateral (that is, on both sides of eight bodies).
Of the eight unilateral, three were of the right side and five of the left. Beaton in his study found that type 1 recorded 90%, type 2 7.1%, type 3 2.1% and type 4 0.8% of the specimens. Mustafa et al. (13) mentioned that in 52% of a studied cases, the SN exited the pelvis as a whole nerve without any division, whereas in 48% a high division was observed. Branches of the SN left the pelvis through the infrapiriform foramen (IP) as two separate nerves in 24%. One branch of the SN left the pelvis through the IP and the other through a different route in another 24%. The study was conducted on 50 gluteal regions in 25 formalin-fixed adult male cadavers. The passage of the SN through the piriformis was also reported by Pecina (25) in 22% of the 130 cadavers. It included penetration of the piriformis by the SN in 5% and presence of the piriformis with two heads in 17%. Ugrenovic et al. (14) found high division of the SN in 27.5% of the specimens in a cadaveric study performed in 100 fetuses. The SN left the pelvis through the IP in 96% of 200 gluteal regions. The CPN passed through the IP in 2.5% of the specimens (type 2), and the CPN passed through the SP and the TN passed through the IP in 1.5% of the cadavers (type 3). Machado et al. (15) performed a gluteus dissection in 100 fetuses and reported three types of the variation, including type 1 where the CPN penetrated the piriformis and TN passed under the piriformis (16%), type 2 where the CPN passed above the piriformis and the TN passed under the piriformis (2.0%) and type 3 where the SN penetrated the piriformis. Chiba (16) reported that CPN passed through the piriformis in 35.8% of the cases by using 511 extremities. Pokorny et al. (17) using 91 fresh cadavers modified the Deaton & Anson classification, and stated that the first variation, undivided nerve below undivided muscle, was the most common type.
and seen in 79.1% of the specimens. Type 2 variation was reported in one case by Arifoglu et al.\textsuperscript{(18)} Type 4 variation, an extremely rare variation, was reported by Chen\textsuperscript{(19)} and by Kosukegawa et al.\textsuperscript{(20)} The type 6 variation, a variation defined hypothetically by Beaton & Anson\textsuperscript{(11)}, was reported in one case by Ozaki et al.\textsuperscript{(21)} and Sayson et al.\textsuperscript{(22)}. The passage of the CPN through the IP, and the passage of the TN under the superior gemellus is also a rare variation which was not described by Beaton & Anson\textsuperscript{(11)}. This variation, to my knowledge, was only reported by Babinski\textsuperscript{(23)} and Mas et al.\textsuperscript{(24)} in one case. This variation may be nominated as Beaton & Anson type 7.
CHAPTER THREE
MATERIAL & METHODS
MATERIAL AND METHOD:

Study design:
The study will be an observational descriptive study.

Study area:
The areas where the study is performed are selected medical schools or colleges of different universities in Khartoum state.

Study population:
The study will be conducted on adult male cadavers fixed in formaline.

Inclusion criteria:
All cadavers that clearly show variations.

Exclusion criteria:
All cadavers that not clearly show variations.

Methods of data collection:
120 lower limb specimens from 60 adult male cadavers(with no pathology) used for this study. The cadavers belong to the Department of Anatomy of many schools or colleges of different Universities. All the cadavers are numbered in a sequential manner and used table design according to Beaton and Anson classification for collecting data of variation. Dissection of the gluteal region is done to expose the gluteus maximus muscle. Gluteus maximus is elevated to show the structures under cover of it. The Piriformis muscle and the relation of sciatic nerve and its branches to the muscle are well observed, photographed and recorded.
**Sample size:**

60 adult male fixed in formaline.

**Sample technique:**

The sample technique is the total coverage.

**Ethical consideration:**

Permission will be obtained from faculty of post graduate studies.
Inform consent from study place

**Data analysis:**

By computer program.
<table>
<thead>
<tr>
<th>University</th>
<th>Number of Cadavers</th>
</tr>
</thead>
<tbody>
<tr>
<td>AlNeelain University</td>
<td>7</td>
</tr>
<tr>
<td>Khartoum University</td>
<td>7</td>
</tr>
<tr>
<td>Omdurman Islamic University</td>
<td>5</td>
</tr>
<tr>
<td>Ahfaad University for Women</td>
<td>5</td>
</tr>
<tr>
<td>Sudan International University</td>
<td>3</td>
</tr>
<tr>
<td>International University of Africa</td>
<td>5</td>
</tr>
<tr>
<td>University of Medical Science and Technology</td>
<td>5</td>
</tr>
<tr>
<td>National Ribat University</td>
<td>9</td>
</tr>
<tr>
<td>AL-Zaiem AL-Azhari University</td>
<td>3</td>
</tr>
<tr>
<td>Bahri University</td>
<td>4</td>
</tr>
<tr>
<td>ALwatania University</td>
<td>7</td>
</tr>
<tr>
<td>Total Number</td>
<td>60</td>
</tr>
</tbody>
</table>

*Table 1: Number of Cadavers Obtained from Each University*
CHAPTER FOUR
RESULTS
4. Results

In this study 60 adult male cadavers so total 120 gluteal regions were examined, 12 showed sciatic nerve variations in relation to the piriformis muscle while 48 were without variations (Based on Beaton and Anson classification).

**Distribution of the the types According to Beaton and Anson Classification.**

In this study and according to Beaton and Anson classification the types that were found type 1 and type 2. Type 1, the undivided sciatic nerve passed below the undivided piriformis muscle (figure 1), this was found in 80% of the specimens while type 2, the sciatic nerve divided into the tibial nerve passing below the piriformis muscle and the common peroneal nerve passing through the piriformis muscle (figure 2 and 3) this was found in 20% of the specimens. Types 3, 4, 5 and 6 were not found in this study.

**Distribution of Type 2 According to Laterality of the variations**

Type 2 variation in this study was observed bilaterally in 7 specimens (figure 4) which represented about 11.66% of the total number of the specimens.

Unilateral presentation of type 2 was found in 5 specimens (Figure 2, 3)(three on the right gluteal region and two on the left), that represented about 8.33% of the total number of the specimens (5% on right and 3.33% on left) table(3).
<table>
<thead>
<tr>
<th>Type</th>
<th>Type1</th>
<th>Type2</th>
<th>Type3</th>
<th>Type4</th>
<th>Type5</th>
<th>Type6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of cases (all male)</td>
<td>48</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>Percentage %</td>
<td>80%</td>
<td>20%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 2: Distribution of Types According to Beaton and Anson Classification

<table>
<thead>
<tr>
<th>Type2</th>
<th>No</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral</td>
<td>7</td>
<td>11.66%</td>
</tr>
<tr>
<td>Unilateral Right</td>
<td>3</td>
<td>5%</td>
</tr>
<tr>
<td>Unilateral Left</td>
<td>2</td>
<td>3.33%</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>20%</td>
</tr>
</tbody>
</table>

Table 3: Distribution of Types According to Laterality of the Variations
Figure (1): The SN exits the pelvis as an undivided nerve through the infrapiriform portion of the greater sciatic foramen in the left gluteal region

Note: PM: piriformis muscle, SN: sciatic nerve
Figure (2): The common peroneal nerve (CPN) passing through the Piriformis muscle (PM) and the tibial nerve (TN) passing through the infrapiriform portion of the greater sciatic foramen in the left gluteal region (unilateral).

Note: LP: lower portional of piriformis, UP: upper portional of piriformis.
Figure (3): The common peroneal nerve (CPN) passing through the Piriformis muscle (PM) and the tibial nerve (TN) passing through the infrapiriformportion of the greater sciatic foramen in the right gluteal region (unilateral).

**Note:** CPN: common peroneal nerve, LP: lower portional of piriformis, TN: Tibial nerve, UP: upper portionl of piriformis
Figure (4): A photograph showing the divided piriformis muscle and the dividing sciatic nerve passing between the two portions of the piriformis muscle (bilateral).

Note: CPN: common peroneal nerve, LP: lower portion of piriformis, TN: tibial nerve, UP: upper portion of piriformis.
CHAPTER FIVE
Discussion
5. Discussion:

Based on different studies appeared in literature, there are many variations. Regarding sciatic nerve division especially in higher divisions. There are different types of high divisions of the sciatic nerve within the pelvis, usually bilateral and if it is unilateral then other side will mostly remain normal. This study demonstrated the existence of these variations in which high SN division was found at the gluteal region and the CPN passes through the PM and the TN passes below it. This condition may lead to compression of these nerves.

The previous studies by Pokorny et al demonstrated that 15 -30% variations between the piriforms and the SN \(^{17}\). In the present study, 80% of the specimens showed emergence of the undivided sciatic nerve below the piriformis muscle. This result support that at Pokorny \(^{17}\), JAJA \(^{26}\), and Ewa \(^{27}\), respectively. However, lower percentages of the sciatic nerve being passed below the piriformis were observed by Guvencer et al \(^{28}\) 52%, Shewala et al \(^{29}\) 73.33% and Uluutku & Kurtoglu \(^{30}\) 74%. In contrast, higher observation 100%, 96%, 91.8%, 90%, 84.4% was reported by Muthu Kumar et al \(^{31}\), Ugrenovic et al \(^{14}\), Beaton et al \(^{12}\), Shailesh et al \(^{32}\), and Beaton & Anson \(^{11}\).

Type 2 variations represented about 20% of the specimens in which the sciatic nerve is divided in the pelvis and its two divisions come out differently. The common peroneal nerve passing through the piriformis muscle while the tibial nerve comes out below the piriformis, this percentage was in the range of that reported in literature (2.5%-
34%\textsuperscript{(13)} that obtained by Pokorny et al\textsuperscript{(17)} (14.3%), Moore KL and Dalley AF\textsuperscript{(2)} (12.2%), Beaton and Anson \textsuperscript{(11)} (11.7%), Uluutk MH, Kurtoglu \textsuperscript{(13)} (16%), Machado et al \textsuperscript{(15)} (16%), and Mustafa et al \textsuperscript{(13)} (16%). The incidence of type 2 is found high when compared with that incidence of type 2 obtained by Chiba \textsuperscript{(16)}. 

In the present study Type 2 variation was seen bilaterally and unilaterally but bilateral occur more than unilateral (11.66% bilateral and 8.33% unilateral) such findings support that reported by Roydon who mentioned that the incidence of bilateral variations is higher than unilateral\textsuperscript{(4)}. Unilateral variations were found three in the right gluteal region and two in left gluteal region. Type 3, 4, 5, and 6 were not found in this study that explain the rare occurrence of these types in the previous studies \textsuperscript{(2,11,12,13,14,15,16)}. The result of this study showed that type "B"-type 2- anomaly is the most common anomaly. Such findings support that reported by Roydon\textsuperscript{(4)}. 

The anatomical variations of the sciatic nerve can contribute to Piriformis Syndrome and sciatica. However, other causes like posterior dislocation of the hip joint, herniated disc or pressure from the uterus during pregnancy may damage the nerve roots and lead to sciatica.

Piriformis syndrome is an uncommon and often undiagnosed cause of buttock and leg pain. It may be caused by anatomic abnormalities of the of the Piriformis muscle which result in irritation of the sciatic nerve. The abnormal passage of the sciatic nerve has been attributed to entrapment of the sciatic nerve as it exits from the greater sciatic notch] in the gluteal region. Knowing of such patterns is also important for surgeons dealing with Piriformis syndrome which affects 5-6% of patients referred for the treatment of back and leg pain.
Knowing the routes of exits of the sciatic nerve is also great importance because the gluteal region is an area of, surgical intervention, deep intramuscular injections, blockage of the sciatic nerve by anesthesia and injury during posterior hip operations (33).
CHAPTER SIX

CONCLUSION & RECOMMENDATION
6. Conclusion and Recommendations

Conclusion:

A good knowledge about the anatomical variation in the formation, course and division of the sciatic nerve and piriformis muscle is more important for surgeons, orthopedicians, anaesthetists and other medical professionals to avoid surgical complications, to prevent failure of sciatic block and to prevent sciatic nerve injury during deep intramuscular injections.

In this study and from the results analysis I found that the commonest variations of the sciatic nerve in relation to the piriformis muscle among Sudanese is type 2 variation in which the sciatic nerve is highly divided at the gluteal region into common peroneal nerve that passes through the piriformis muscle and tibial nerve which passes below the piriformis muscle. Also we found that type 2 variation was found bilaterally more than unilaterally in the specimens that showed variations.
Recommendations

1- Knowledge of variation in division of the sciatic nerve in the gluteal region is very important for a surgeon, as this is an area of frequent surgical manipulation. This knowledge will not only help the surgeon to take care during surgery, but also help to plan accordingly during various surgical intervention and management of this region.

2- Knowledge of sciatic nerve variation is very important for nurses and junior doctors to prevent hazards of deep intramuscular injection.

3- Radiologists should have a good knowledge of the variation between the sciatic nerve and piriformis muscle which may complicate radiographic interpretations.
REFERENCES
References

7. en.m Wikipedia.org piriformis muscle


