VARIATIONS INTHE COURSE, DISTRIBUTION AND TERMINATION OF THE SCIATIC NERVE IN A SELECTED ADULT KENYAN POPULATION

BY

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A RESEARCH THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF MEDICINE IN ORTHOPAEDIC SURGERY, MOI UNIVERSITY, SCHOOL OF MEDICINE

DECLARATION

Declaration by the Student

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DEDICATION

This study is dedicated to the author’s family, for their endless source of inspiration and support of the author’s academic career in orthopaedic surgery.

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LIST OF ABBREVIATIONS AND ACRONYMS

IREC Institutional Research and Ethics Committee

L1 First lumbar spinal nerve

MTRH Moi Teaching and Referral Hospital

S1 First sacral spinal nerve

THA Total hip arthroplasty

AC Distance between the lowest point of the ischial tuberosity and the medial edge of the sciatic nerve

BD Distance between the tip of the greater trochanter and the lateral edge of the sciatic nerve

AB Distance between the tip of the greater trochanter and the lowest point of the ischial tuberosity.

DEFINITION OF TERMS

Adult Anyone above the age of 18 according to the Constitution of Kenya

Course The route traversed by the nerve in relation to the greater trochanter of the femur and the ischial tuberosity

Distribution The spreading out of the branches of the sciatic nerve to supply the hamstring muscles

Termination The end of the sciatic nerve where it divides into its terminal branches

Variations Deviations from the normal or classical description

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ABSTRACT

Background: Anatomical variations for the sciatic nerve have been described on the relationship of the nerve to the piriformis muscle and its termination point. Few studies have been conducted on the relationship of the nerve to bony landmarks in the gluteal region. Global, regional and local published data on the latter is limited. The sciatic nerve is the largest terminal branch of the sacral plexus. It gives branches to the hip joint and the hamstring muscles before it terminates into the tibial and common peroneal trunks. The nerve is usually in the operative field during posterior approaches to the hip joint and hence should be looked for.

Objective: To describe variations in the course, distribution and termination of the sciatic nerve in a selected adult Kenyan population.

Methods: This was a descriptive anatomical cross sectional study that was conducted at the Department of Human Anatomy of Moi University. Ethical approval was sought from Institutional Research and Ethics Committee. Sixty three left lower limbs, that met the inclusion criteria, were dissected as detailed in the Cunningham's Manual of Practical Anatomy, 15^{th} edition. This was illustrated using photographs. Descriptive statistics such as frequencies and percentages were used for categorical variables while measures of central tendency and measures of spread were used for continuous variables.

Results: In most cases the sciatic nerve passed through the midpoint between the greater trochanter of the femur and the ischial tuberosity (50.8%) or medial to it (46.03%). For any given nerve branch to the hamstring muscles, the branching occurred distal to the ischial tuberosity (>90%) and in the upper half of the thigh (>83%). However, branching to the short head of biceps femoris occurred in the lower half of the thigh in 23.8% of cases. The long head of biceps femoris had one , two or three branches in 47.62%, 42.86% and 9.52% of specimens respectively. Semitendinosus and semimembranosus muscles had one or two branches (90.48% versus 9.52%). Short head of the biceps femoris muscle was supplied by a single branch in all specimens.The hamstring part of the adductor magnus muscle had one or two branches (98.41% versus 1.59%).The sciatic nerve terminated in the thigh in sixty-two (62) cases and in the pelvis in one (1) specimen only.In instances where the sciatic nerve terminated in the thigh, this happened mostly in the lower third (80.65%) compared to the middle third (19.35%).

Conclusion: The course and termination of the sciatic nerve was found to be similar to the findings in the previous studies conducted locally, regionally and globally. However, more branches to some of the hamstring muscles were found in this study compared to the few studies conducted globally.

Recommendation: Caution should be taken when placing retractors at, or medial to the midpoint between the greater trochanter of the femur and the lowest point of the ischial tuberosity. Surgeons should minimise dissections through inter- muscular planes in the upper part of the thigh.

CHAPTER ONE: INTRODUCTION

1.1 Background information

The sciatic nerve is the largest terminal branch from the sacral plexus. It is formed inside the true pelvis anterior to the piriformis muscle by union of the ventral rami of the last two lumbar spinal nerves and the first three sacral spinal nerves (L4, 5; S1, 2, 3). Its proximal part is covered by the gluteus maximus where it rests on the posterior surface of the ischium with the nerve to the quadratusfemoris lying deep to it. It descends posterior to the tendon of obturatorinternus, the gemelli muscles and thequadratusfemoris muscle. The latter separating it from the obturatorexternus and the capsule of the hip joint (Shewale et al., 2013). The posterior cutaneous nerve of the thigh and the inferior gluteal artery lie medial to the nerve and it is crossed from medial to lateral by the long head of the biceps femorismuscle in the posterior compartment of the thigh. Its surface marking corresponds to a line drawn from just medial to the midpoint between the greater trochanter and the ischial tuberosity to the apex of the popliteal fossa (Standring S., 2016).

The nerve is contained within a single sheath of epineurium, but structurally comprises of two trunks (Shewale et al., 2013). The tibial nerve which is formed by the anterior divisions of the ventral rami of L4, L5, S1, S2, and S3, and the common peroneal nerve formed by the posterior divisions of the ventral rami of L4, L5, S1, and S2. The common peroneal trunk lies laterally and is more vulnerable to injury during posterior approach to the hip joint (Oldenburg , 1997).

Sciatic nerve palsies are uncommonfollowing primary total hip arthroplasty (THA) but the few patients who sustain nerve injuries intra-operatively go through a lot of debilitating neurological symptoms. A third of patients with motor nerve palsy will have complete motor recovery after an average period of 21.1 months (Farrell et al., 2005).

Articular branches to the hip joint reach it from the posterior aspect and are given off in the gluteal region. Muscular branches to semitendinosus, semimembranosus, long head of biceps femoris and the ischial part of adductor magnusmuscles usually come from the tibial trunk while the common peroneal trunk supplies the short head of the biceps femorismuscle (Woodley & Mercer, 2005). The site of division for the sciatic nerve into its tibial and common peroneal branches is variable. Apart from leaving the pelvis as a single nerve, the nerve may divide inside the pelvis and the two trunks reach the lower limb through different routes which may be related to a divided piriformis muscle (Beaton & Anson, 1937).

1.2 Problem Statement

One of the well established complications of THA is iatrogenic sciatic nerve injury which is associated with high morbidity. Four cases of iatrogenic sciatic nerve injuries were seen at MTRH and Saint Luke’sHospital in 2015 following THA.

This incidence is higher than that reported in the literature, andTHA and acetabularsurgery arebeing done more frequently than before at MTRH.

1.3 Justification

Familiarity with the anatomy, and its variations for nerves that are at risk during any surgical procedure is very crucial for avoiding intra-operative nerve injuries. The findings of this study will familiariseorthopaedic surgeons with the variant relations of the sciatic nerve to the greater trochanter of the femur and the ischial tuberosity.

In addition, studies on the sciatic nerve have revealed variations in its course within and between populations.Despite these documented findings, to our knowledge, no studies have been conducted locally and regionally on the variant relations of the nerve to bony landmarks in the gluteal region and on the distribution of the nerve to the hamstring muscles.

Peripheral nerve blockade is becoming popular as an analgesic option for both upper and lower limb surgery. It provides superior levels of analgesia in the immediate postoperative period when compared with traditional opioid techniques and is associated with high levels of patient satisfaction.Anaesthetists and/or surgeons can use the findings of this study to perform safesciatic and popliteal blocks. The communities in rural areas can benefit a lot from this cheap procedure that has few side effects compared to general anaesthesia.

Rehabilitation of amputees in the modern world involves the use of myoelectric prosthetic devices. The success of these devices requires the presence of nerve-muscle units in the stump. Surgeons who are familiar with the innervation of the hamstring muscles can ensure that the nerve-muscle units are preserved as much as it is possible especially in trauma patients where the anatomy is distorted. This will help patients avoid surgical complications associated with re-innervation procedures.

To our knowledge, the anatomy of the sciatic nerve in relation to the bony landmarks in the gluteal region and its distribution to the hamstring muscles has not been studied locally and the literature is limited globally. The findings of this study will be useful in filling this gap.Finally, a reduction in the number of iatrogenic sciatic nerve injuries will keep to a minimum the morbidity, disability and number of medico legal claims that are likely to follow as patients become more enlightened on their rights.

1.4 Research Question

What are the variations in the course, distribution and termination of the sciatic nerve in a selected adult Kenyan population?

1.5 Objectives

1.5.1 Main objective

To describe the variations in the course, distribution and terminationof the sciatic nervein a selectedadult Kenyan population

1.5.2 Specific objectives

1. To determine the variations in the course of the sciatic nerve in relation to the greater trochanter of the femur and the ischial tuberosity in a selected adult Kenyan population.
2. To describe the distribution of the sciatic nerve to the hamstring muscles in a selected adult Kenyan population.
3. To describe the termination point of the sciatic nerve into its terminal branches in the upper, middle and lower thirds of the thigh in a selected adult Kenyan population.

CHAPTER TWO: LITERATURE REVIEW

2.1 Overview

The sciatic nerve is the largest terminal branch of the sacral plexus. It is formed by the union of the ventral rami of L4-S3 spinal nerve roots. In 73.3 % to 93.6 % of cases, the 2cm wide nerve enters the gluteal region by passing through the greater sciatic foramen inferior to the piriformismuscle and descends between the greater trochanter of the femur and the ischial tuberosity (Beaton et al., 1937;Divizyon, 2009; Natsis et al., 2013;Ogeng'o et al., 2011; Pokorny et al., 2006).The undivided nerve, which is formed by the ventral rami of spinal nerves, actually comprises of atibial trunk formed by the anterior divisions of L4-S3 and a common peroneal trunk which comprises of the posterior divisions of L4-S2 (Vloka et al., 2001). Along its course, it lies superficial to the superior gemellus, obturatorinternus tendon, inferior gemellus and the quadratusfemoris muscles.

Variations from the common course traversed by the nerve exist and have been studied using cadavers of different races, age and sex. The relationship of the nerve to the piriformis muscle as it exits the pelvis is very variable (Chiba, 1992;Smoll, 2010). The termination of the sciatic nerve has also been reported to be variable in several studies (Ogeng'o et al., 2011; Prakash et al., 2010; Shewale et al., 2013).

The piriformis muscle is in close relation to the sciatic nerve as it leaves the pelvis to reach the gluteal region. It is a landmark for easy identification of structures in the gluteal region (Natsis et al., 2013). The muscle originates from the lateral border of the sacrum, the anterior surface of the second, third and fourth segments of the sacrum, the superior margin of the greater sciatic notch and the sacrotuberous ligament. The muscle leaves the pelvis through the greater sciatic foramen to insert on the superior part of the greater trochanter of the femur. The greater sciatic foramen is bounded superiorly andanteriorly by the greater sciatic notch, posteriorly by the sacrum and the sacrotuberous ligament and inferiorly by the sacrospinous ligament (Guvencer et al., 2008).

2.2 Variations in the course of the sciatic nerve in relationtothe greater trochanter of the femur and the ischial tuberosity

The greater trochanter of the femur and the ischial tuberosity are prominent landmarks in the gluteal region. Distances from these consistent bony landmarks to the sciatic nerve were looked into in very few studies. The distance from the most lateral point of the greater trochanteric ridge to the lateral edge of the sciatic nerve on MRI films has been reported to be 4.83 ± 0.26 centimetres (Wang et al., 2016).

The distance between the lateral edge of the sciatic nerve and the apex of the greater trochanter of the femur has been reported as 4.28 ±0.44 centimetreson cadavers of Turkish origin (Guvencer et al., 2008). In the same study, they also measured the distance from the most inferior edge of the ischial tuberosity to the medial edge of the sciatic nerve and reported2.2 ±0.42 centimetres. For the distance between the greater trochanter of the femur and the lowest point of the ischial tuberosity they reported 7.416 ± 0.504 centimetres. From these measurements, the latter study indicates that thesciatic nerve is located medial to the midpoint of the distance between the greater trochanter of the femur and the ischial tuberosity.

According to Watts et al., (2007), the relation of the sciatic nerve to the bony landmarks is of use during peripheral nerve blocks. Sciatic nerve or popliteal fossa blocks are performed to provide postoperative analgesia after foot surgery or for lower limb symptoms associated with intervertebral disc pathology. The popliteal fossa block has an advantage over the standard sciatic nerve block because the hamstring function is maintained.

The common causes of iatrogenic injuries to the sciatic nerve are gluteal area injections, intraoperative injuries and vascular insults (Yeremeyeva et al., 2009). The intraoperative injuries are mainly orthopedic and even though they are the second common cause, the associated morbidity is debilitating as in those who sustain injection injuries (Wolf et al., 2014).

Sciatic nerve palsies following total hip arthroplasty are associated with preoperative diagnosis of developmental dysplasia, posttraumatic arthritis, posterior approach, lengthening of the extremity and cementless femoral fixation (Edwards et al., 1987; Farrell et al., 2005; Pokorny et al., 2006; Schmalzried et al., 1991). During total hip arthroplasty, posterior approach to the hip joint carries a greater risk of sustaining a nerve palsy compared to the anterolateral and the transtrochantericapproaches (Farrell et al., 2005).Reduction manoeuvres, retractor placement and leg positioning during the preparation of the canal for the implant during hip arthroplasty have also been implicated (Weber et al., 1976).Other aetiologies of note include postoperative haematoma, heat of polymerizing cement and compression by surgical materials like clips, cerclage wires and rarely by sutures(Pokorny et al., 2006).

From the literature, it shows that the incidence for peroneal nerve, sciatic nerve and femoral nerve injuries range from 54% to 64%, 21% to 30% and 6% to 25% respectively (Farrell et al., 2005; Oldenburg & Muller, 1997).The peronealtrunk of the sciatic nerve and the sciatic nerve injuries combined account for more than 80% of the insults (Schmalzried et al., 1991). Isolated insults to the tibial nerve are rare. In a systematic database review comparing the posterior against the lateral approach for total hip arthroplasty in adults with osteoarthritis, it was reported that the overall risk of any nerve palsy was greater in the direct lateral approach. Nevertheless, there was no significant difference seen when comparing the risk for the sciatic nerve injury during both approaches (Jolles&Bogoch, 2004).

A study on the iatrogenic injuries to the sciatic nerve during surgical repair of acetabular fractures indicated that theilioinguinal approach was associated with more injuries compared to the Kocher-Langenbeck approach with a prevalence of 6.5% and 4.4% respectively (Haidukewych et al., 2002). The possible explanation is that with the ilioinguinal approach, the reduction manoeuvres of the posterior column are done when the nerve is under tension due to flexion of the thigh (Cutrera et al., 2015). In a case series on the classification and management of acetabular fractures focusing on 582 acetabular fractures, sciatic nerve palsy among those operated within three weeks of injury was 12% but they did not report on those operated three weeks or more post injury (Letournel E., 2007).

According to the British Orthopaedic Association (BOA) guidelines, all surgical approaches for total hip replacement must provide a full view of all of the face of the acetabulum, they should allow adequate delivery of the proximal femur into the wound and also maximise maintenance of the integrity of the abductor mechanism and the fascia lata (Sloan et al., 2010). Many studies have shown that the surgical procedure on its own is not an independent cause of neurovascular injury during THA (Farrell et al., 2005; Oldenburg et al., 1997; Pokorny et al., 2006).

The common surgical approaches to the hip joint include: posterior (Southern) approach for total hip arthroplasty, hemiarthroplasty of the hip, posterior wall and column acetabular fracture open reduction and internal fixation, open reduction of posterior hip dislocations, and hip arthrotomy.During this approach, the patient is placed in the lateral decubitus position with supports placed anteriorly over the anterior superior iliac spine, and posteriorly over the sacrum. Alternatively the anterior support may be placed against the pubic symphysis(Moretti& Post, 2017). Proper marking of the greater trochanter and the proposed incision prior to limb preparation and draping will ensure that the requirements for total hip arthroplasty listed in the British Orthopaedic Association guidelines are met. A 15-20cm incision cantered 50% over the posterior 1/3 of the greater trochanter and 50% proximal to the trochanter at a 45^0 angle posteriorly, is usually adequate (Sloan et al., 2010).

Dissection through the skin and subcutaneous tissues exposes the deep fascia which is then opened at the distal end of the wound. Slight abduction of the limb will assist with this part. The gluteus maximusmusclefibres are split proximally by blunt dissection to visualize the greater trochanter and the posterior aspect of the hip with the aid of a retractor. The sciatic nerve must be identified at this stage and tagged for ease of protection throughout the procedure. The interval between gluteus minimus and piriformis muscles is opened with diathermy and the retractor is then repositioned under minimus. The joint can be accessed by taking the external rotators and the capsule in two layers (Hedley et al., 1990). A suture is placed through the piriformis, gemelli and obturatorinternus tendons before they are released as close as possible to the bone. The quadratusfemoris muscle is released leaving enough tissue to repair on closure. Capsulotomy can then be performed to access the joint. The sciatic nerve may be injured directly, by retractors, or during repair of external rotators and the capsule when closing. In total hip replacement, the nerve can be injured when the limb is lengthened excessively during the procedure (Farrel et al., 2005).

Posterior approach to the acetabulum (Kocher- Langenbeck) which is indicated for posterior wall fracture, posterior column fracture, associated posterior column/wall fractures, and transverse acetabular fracture with posterior displacement has the risk for iatrogenic sciatic nerve injury as a concerning complication (Haidukewych et al., 2002). It can also be used for T-type fractures. Patients can be placed in the lateral decubitus orprone position, depending on the fracture pattern. The latter eliminates gravity as apotential deforming force and allows for easier hip extension and knee flexion to relieve tension on the sciatic nerve (Cutrera et al., 2015). The approach almost resembles the posterior approach to the hip joint but to access the acetabular dome requires division of the gluteus medius and minimus at the greater trochanter. Acetabular surgery may require access to the inner wall of the ilium through the lesser sciatic notch and palpation of the quadrilateral surface through the greater sciatic notch. Mechanism of sciatic nerve injury includes excessive retraction which may include placement of retractors into the sciatic notches, intraoperative manipulation of bony fragments, or entrapment of the nerve by clamps used for fracture reduction (Yeremeyeva et al., 2009). The posterior acetabular retractor during THR has been found to be the closest to neurovascular structures compared to other retractors used during the preparation of the acetabulum (Shubert et al., 2015).

2.3 Distribution of the sciatic nerve to the hamstring muscles

The tibial trunk innervates the semitendinosus muscle and the long head of the biceps femoris muscle with two branches each and gives one branch to the semimembranosusmuscle. Thetibial trunk also gives a branch to the hamstring part of the adductor magnus muscle. The short head of the biceps femoris muscle receives a single branch from the common peronealtrunk (Woodley &Mecer, 2005).

The nerve entry points of the hamstring muscles and their intramuscular arborisationhave been studied by staining using the modified Sihler method (Rha et al., 2016). Reported as percentages of the distance from the plane connecting tibial condyles to the ischial tuberosity, they noted two areas of arborisation for the biceps femoris muscle at 15% – 30% and 50% – 60% of the way. Two areas were seen at

25% – 40% and 60% – 80% for semitendinosus muscle and at 20% – 40% for the semimembranosus muscle corresponding to the number of nerve entry points to the individual muscles found during dissection. These patterns of nerve distribution are of use during management of spasticity using botulinum toxin injections (Rha et al., 2016).

2.4 Termination of the sciatic nerve

Motor axons to the muscles of the lower limb have been found to leave the spinal cord to enter the limb bud during the fifth week of development to form the lumbar and sacral plexuses. As the plexuses grow the rami forming them are divided into the anterior and posterior divisions. The sciatic nerve is formed when the common peroneal trunk, which is the largest posterior component, and the tibial trunk, which is the largest anterior component grow down in close proximity into the muscles of the lower limb (Moore K.L., 2008). In situations where the intact nerve leaves the pelvis below the piriformis muscle, it terminates by dividing into the common peroneal nerve and the tibial nerve anywhere in the gluteal region, the posterior compartment of the thigh or in the popliteal fossa (Prakash et al., 2010). Division of the sciatic nerve high in the pelvis has been reported and it is sometimes associated with divided piriformis muscle (Demiryurek D., 2002)

A cadaveric study on the sciatic nerve among the Indian population reported that the nerve divides into its terminal branches in the lower part of the posterior compartment of the thigh and the popliteal fossa in 40.7% and 34.9% of cases respectively (Prakash et al., 2010).A higher incidence of 63.33% for the division of the nerve at the superior pole of the popliteal fossa was found in another study in India (Grewal et al., 2016).A different study conducted still in India indicated that the nerve terminated in the lower part of the thigh near the superior angle of the popliteal fossa in 73.33% of cases on the right and in 76.67% of cases on the left among males and in 60% of cases in females for both left and right limbs. In the same study, the nerve terminated in the popliteal fossa in 6.67% of cases in males both on the right and on the left. In females, the nerve terminated in the popliteal fossa in 6.67% of cases on the right and in 13.33% of cases on the left (Shewale et al., 2013). The incidence of the nerve dividing in the popliteal fossa can be as high as 92% (Adibatti et al., 2014).

Popliteal division for the sciatic nerve in a Polish population was found to be 72.2% (Okraszewska et al., 2002) while it was in 72.5% of cases in a Turkish study (Ugrenovic et al., 2005). In another cadaveric study conducted in East Africa (Ethiopia), the nerve trifurcated in the popliteal fossa in 5% of the cases only which was a rare finding in the literature (Berihu&Debeb, 2015) From the above studies, the division of the sciatic nerve into its terminal branches in the popliteal fossa is very variable within and between populations as indicated by a range of 5% to 92%.

The sciatic nerve is reported to divide into the common peroneal nerve and the tibial nerve at a distance of 50 to 180 mm above the popliteal crease (Saleh et al., 2009).

Regionally, in a cadaveric study conducted at Makerere University the sciatic nerve terminated in the gluteal region and the posterior thigh in 77.5% of casesand they found a mean vertical perpendicular distance of bifurcation above the transverse popliteal crease of 8.5 +/- 1.4 cm (Kukiriza et al.,2010).In another study conducted locally at University of Nairobi on cadaveric limbs of adult black Kenyans, the nerve was found to divide into its terminal branches in the popliteal fossa and the middle third of the thigh in 67.1% and 10.4% of cases respectively (Ogeng'o et al., 2011)

CHAPTER THREE: METHODOLOGY

3.1Study Design

This was a cross sectional anatomical study. The study duration was from December 2018 to June 2019.

3.2 Study site

The study was conducted in the Department of Human Anatomy Laboratories, MoiUniversity. Moi University is based in Moi Teaching and Referral Hospital (MTRH).MTRH is situated along Nandi road, in Eldoret, country's fifth largest town, the headquarters of UasinGishu County in the North Rift of Kenya. It is located approximately320kilometersnorth west of Nairobi, the capital city of Kenya. MTRH was upgraded from former UasinGishu District Hospital (UGDH) in late 1990s; however another UGDH was established on temporary basis along Uganda road in Eldorettown.

MTRH is a tertiary health institution with close to 1000 total bed capacity; it is the second largest teaching and referral hospital in the country after Kenyatta National Hospital. It serves as a teaching hospital for Moi University College of health sciences. Several other scholars from various educational institutions come to this hospital for attachments.

It also serves as a referral health institution with a wide catchment area including Western part of Kenya, Eastern part of Uganda and Southern Sudan with at least 20 million people, almost half the population of Kenya.

3.3 Study Population

Cadavers of a selected adult Kenyan population from the Department of Human Anatomy Laboratory were used in this study. The cadavers were sourced from MTRH mortuary and were from a selected region, Western Kenya, which is part of the MTRH catchment area.

3.4 Eligibility Criteria

3.4.1 Inclusion Criterion

Lower limbs from cadavers of adult Kenyans were included. Only cadavers or limbs with preserved anatomy were used in this study.

3.4.2 Exclusion Criterion

Limbs deformed due to trauma or any medical conditions were excluded.

3.5 Sample size determination

The Department of Human Anatomy at Moi University could avail a minimum of fifty-five one sided lower limbs per year. A census study was conducted on 63 left lower limbs of adult Kenyan cadavers that met the eligibility criteria.

Even though cadaveric studies suggest no marked differences between the right and left sides of the body, only left extremities were dissected to avoid the situation of missing limbs where they were already detached from the bodies.

3.6Materials and Methods

Sixty three (63) formalin preserved left lower limbs were dissected in this study. Dissection of the limbs was done according to Cunningham's Manual of Practical Anatomy, 15th edition (Romanes G.J., 2003). The limbs were placed in the prone position during dissection with both the hip and the knee joints extended. The skin was dissected along a line extending posteriorly along the iliac crest from a point in the coronal plane to the cleft between the buttocks. The line kept the same curvature from the inferior end of the cleft to the saggital plane midway along the length of the thigh. A vertical incisionthat bisects the posterior aspect of the popliteal fossa was then extended proximally to meet the first incision. The skin was reflected to expose and measure the length of the thigh, from the gluteal fold to the popliteal crease, which was thenrecorded on the data collection sheet (*Appendix 1*). The gluteusmaximus was cut verticallytwo to three centimetres medial to its femoral insertion; from below upwards before the muscle flaps were reflected to expose the structures underneath. Fat and connective tissue were removed to expose the sciatic nerve, greater trochanter of the femur and the ischial tuberosity.

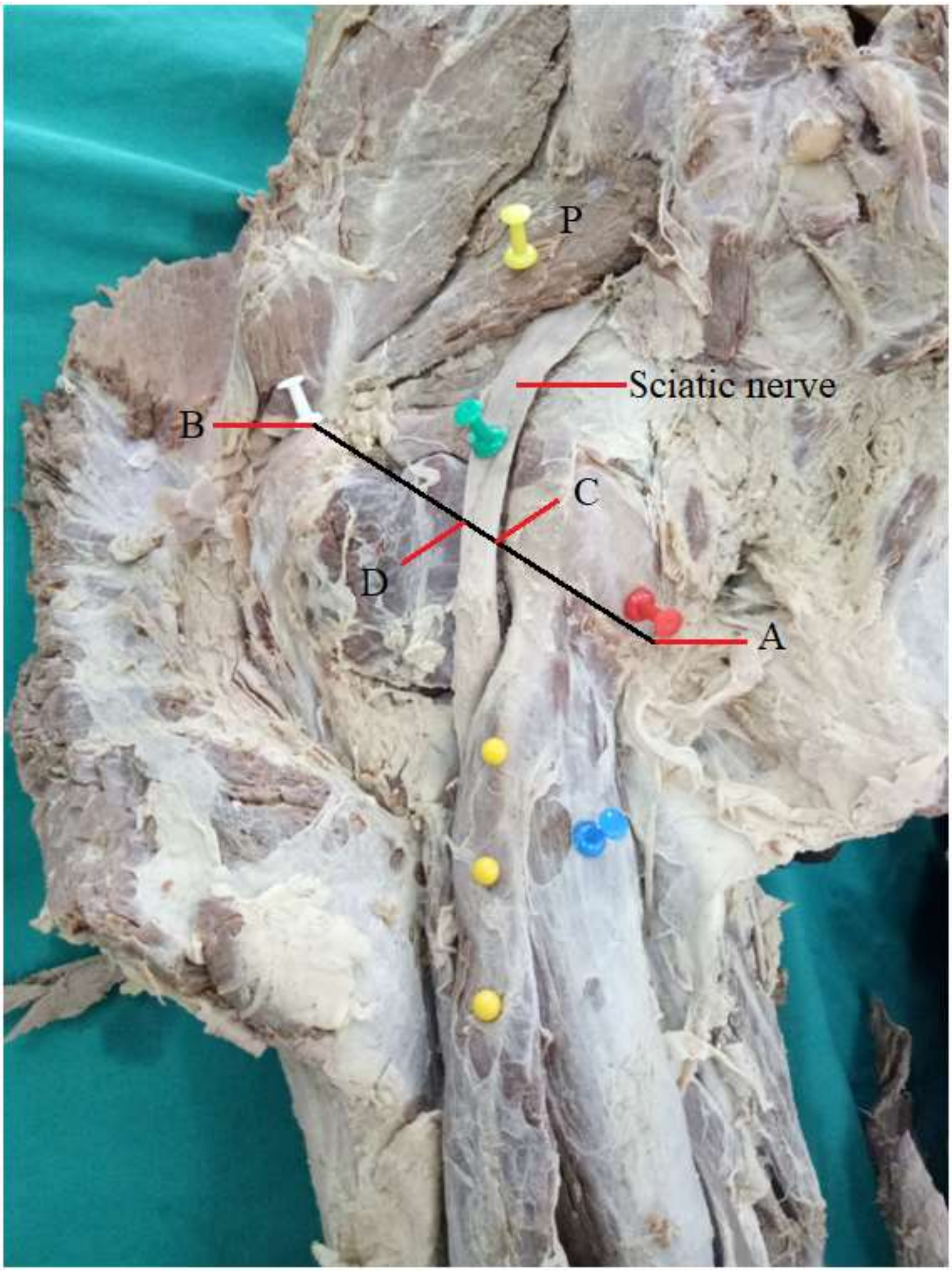

Figure 3.6.1: Left gluteal region showing the sciatic nerve emerging below the piriformis muscle. (P- piriformis muscle; A- lowest point of ischial tuberosity; B- tip of the greater trochanter; Black Line – Distance AB; C-medial edge of sciatic nerve; D- lateral edge of sciatic nerve; Blue pin – semitendinosus muscle; Yellow beads –Long head of biceps femoris muscle).

Distances from the tip of the greater trochanter and the ischial tuberosity to the lateral and medial edges of the sciatic nerve were then measured respectively (Figure 3.6.1). All measurements were taken using a digital calibrated calliper (Neiko Tools digital verniercalliper) accurate to 0.01 millimetres and were recorded in centimeters.

Excess connective tissue was then removed to separate the bellies of the hamstring muscles in order to identify their nerve supply. The points at which the branches to the hamstring muscles leave the sciatic nerve werethen measured from the lowest point of the ischial tuberosity and recorded. The muscular branches leaving the sciatic nerve, the tibial nerve and the common peroneal nerve to supply eachof the hamstring muscles were numbered in a sequential order with the most proximal being branch number one (Branch 1). It was also recorded if the muscular branches were given off from the trunks of the sciatic nerve either proximal or distal to the ischialtuberosity. The point of termination of the sciatic nerve into its terminal branches was measured along a perpendicular line from the popliteal crease.All dissected specimen were labelled and kept for future references.

3.7 Data Management, Analysis and Presentation

The data collected was transferred into an electronic database in order to facilitate safe storage and statistical analysis with ease. Upon completion of this exercise, the used data collection forms were then shredded before safe disposal. A backup copy of the data was created and saved in a computer with a password encryption.

The STATA software (Version 15) was used to analyse the data collected. Categorical data has been summarized in the form of frequency tables, while continuous data has been summarized in the form of mean, median and standard deviations. After analysis, the data was presented in the form of tables, pictures and figures.

3.8Ethical Considerations:

Permission to proceed with the study was sought from The Department of HumanAnatomy and Institutional Research and Ethics Committee (IREC) of MTRH/Moi University. The study approval number was IREC 0002064.The cadavers were handled according to the Anatomy Act (Chapter 249), Revised Edition 2012(1968) of The Republic of Kenya.

3.9 Study limitations

Handling of the extremities during dissection could cause shifting of the sciatic nerve from its anatomical position. This was minimised by anchoring the nerve to the underlying soft tissues using hypodermic needles immediately after reflecting the gluteus maximus muscle.

CHAPTER FOUR: RESULTS

4.1 The relation of the sciatic nerve to the greater trochanter of the femur and the ischial tuberosity

In all the 63 gluteal regions of the dissected specimens, the sciatic nerve left the pelvis through the greater sciatic notch and took a inferolateral course to pass between the greater trochanter of the femur and the ischial tuberosity. In instances where the nerve divided inside the pelvis, one case in this study, the two trunks also took the same course descending superficial to the superior gemellus muscle, tendon of obturato rinternus muscle, inferior gemellus muscle and quadratusfemoris muscle to enter the posterior compartment of the thigh.

4.1.1 The mean distances between the sciatic nerve and the greater trochanter of the femur and the ischial tuberosity

The mean distance between the lowest point of the ischial tuberosity and the medial edge of the sciatic nerve (AC) was measured as 3.61+/- 2.02 cm and the mean distance between the tip of the greater trochanter and the lateral edge of the sciatic nerve (BD) was measured as 4.69 +/- 0.85 cm (Figure 4.1.1.1).The mean distance between the tip of the greater trochanter and the lowest point of the ischial tuberosity (AB) was measured as 9.43+/- 1.08 cm (Table 4.1.1.1). In the case where the nerve divided in the pelvis, the distances were measured from the lateral edge of the common peroneal branch and the medial edge of the tibial branch of the sciatic nerve.

Table 4.1.1.1: The mean distances between the sciatic nerve and the greater trochanter of the femur and the ischial tuberosity

Parameter	Mean distance (cm)
AC	3.61 +/- 2.02
BD	4.69 +/- 0.85
AB	9.43 +/- 1.08

Definition of Parameters : AC - Distance between the lowest point of the ischial tuberosity and the medial edge of the sciatic nerve; BD - Distance between the tip

of the greater trochanter and the lateral edge of the sciatic nerve; AB - Distance between the tip of the greater trochanter and the lowest point of the ischial tuberosity.

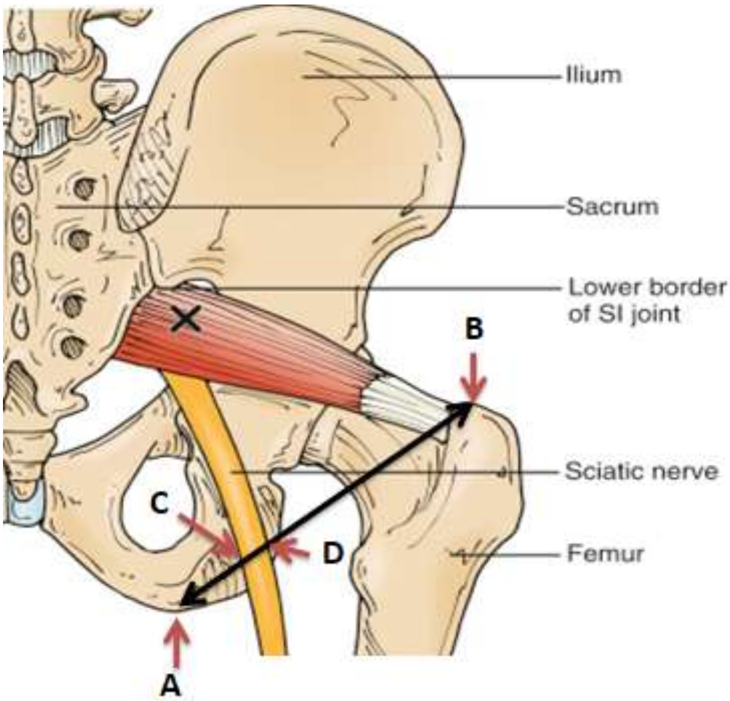

Figure 4.1.1.1: Posterior view of the pelvis showing the right gluteal region. Parameters: AB (Black line) – The distance between the tip of the greater trochanter of the femur and the lowest point of the ischial tuberosity; AC – The distance between the lowest point of the ischial tuberosity and the medial edge of the sciatic nerve; BD – The distance between the tip of the greater trochanter and the lateral edge of the sciatic nerve (Adapted from Sciencedirect.com).

4.1.2 The position of the sciatic nerve between the greater trochanter of the femur and the ischial tuberosity

In most cases, 32 out of 63 (50.79%), the sciatic nerve was found midway between the greater trochanter of the femur and the ischial tuberosity. The whole nerve was found medial to the midpoint between the two bony landmarks in 29 out of 63 (46.03%) of specimens (Table 4.1.2.1). In only 2 out of 63 (3.17%) cases the whole nerve was lateral to the midpoint between the two bony landmarks. In 61out of 63 (96.83%) of cases in this study, the whole sciatic nerve or part of it was medial to the midpoint between the two bony landmarks. The latter includes the case where the nerve divided inside the true pelvis.

Table 4.1.2.1: Position of the sciatic nerve between the greater trochanter of the femur and the ischial tuberosity

Position of the nerve	Frequency	Percentage
Medial to midpoint	29	46.03%
Lateral to midpoint	2	3.17%
Through midpoint	32	50.80%
Total	63	100%

4.2 Distribution of the sciatic nerve to the Hamstring muscles

4.2.1Branches of the sciatic nerve to the hamstring muscles (biceps femoris, semimembranosus, semitendinosus and hamstring part of the adductor magnus).

The long head of the biceps femoris muscle was innervated by one branch in 30 out of 63 (47.62%) specimens and it received two nerve branches in 27 out of 63 (42.86%) of cases.

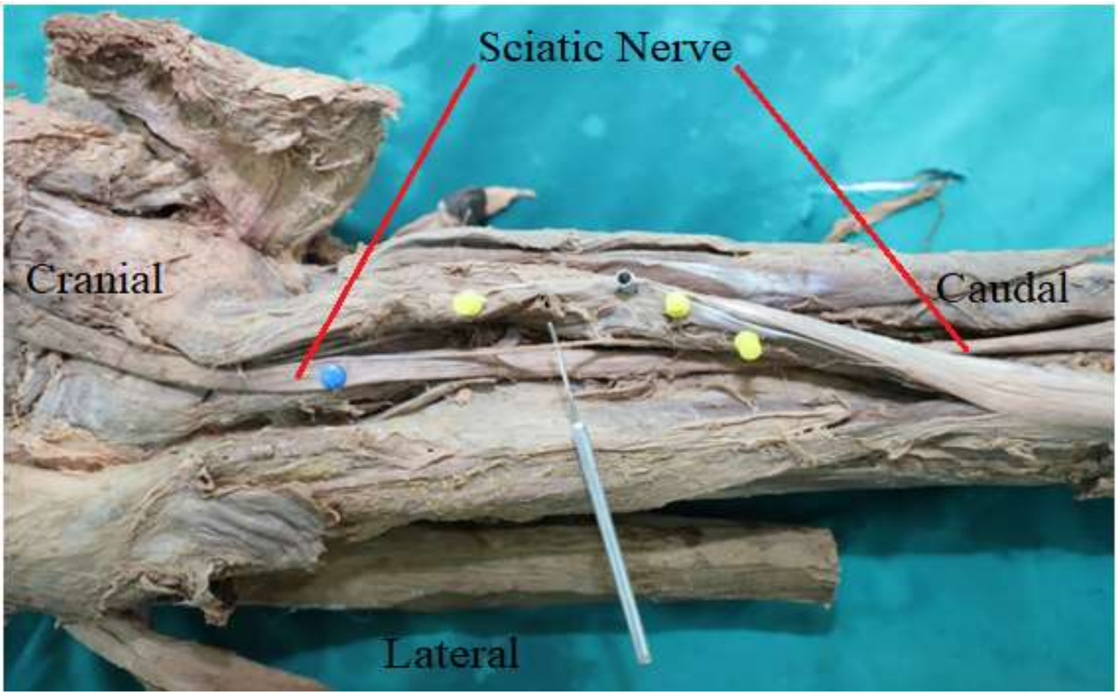

Figure 4.2.1.1: The upper part of the posterior compartment of the thigh showing a nerve branch to the long head of the Biceps Femoris muscle(Elevated with stainless steel hook)(Yellow pins- long head of Biceps Femorismuscle reflected medially; Blue pin- sciatic nerve).

It was innervated by three branches in 6 out of 63 (9.52%) cases only (Table 4.2.1.1). Semitendinosus muscle was innervated by one branch in 57 out of 63 (90.48%) cases and two branches in 6 out of 63 (9.52%) cases. Semimembranosus muscle was innervated by one branch in 57 out of 63 (90.48%) cases and two branches in 6 out of 63 (9.52%) cases.

The short head of the biceps femoris muscle was innervated through a single nerve branch in all the specimens. The hamstring part of the adductor magnus muscle received a single nerve branch in 62 out of 63 (98.41%) cases and received two branches in only one (1.59%) specimen.

Table 4.2.1.1: Distribution of the sciatic nerve to the hamstring muscles

Muscle	Frequency of number of branches(Percentage)		
	1 Branch	2 Branches	3 Branches
Long head of biceps femoris	30 (47.62%)	27 (42.86%)	6 (9.52%)
Semitendinosus	57 (90.48%)	6 (9.52%)	0
Semimembranosus	57 (90.48%)	6 (9.52%)	0
Short head of Biceps femoris	63 (100%)	0	0
Hamstring part of adductor magnus	62 (98.41%)	1 (1.59%)	0

4.2.2 The relation of the nerve branches supplying the hamstring muscles to the ischial tuberosity

When all the nerve branches were treated separately, a significant fraction of the branches of the sciatic nerve supplying the hamstring muscles were given off distal to the ischial tuberosity. Branches to the long head of the biceps femoris muscle were given off distal to the ischial tuberosity in 96 out of 102 (94.22) cases and proximal to the ischial tuberosity in 6 out of 102 (5.88%) cases. All the branches to the semitendinosus and hamstring part of the adductor magnus muscles were given off distal to the ischial tuberosity (Table 4.2.2.1). Nerve branches to the semimembranosus muscle were given off distal to the ischial tuberosity in 68 out of 69 (98.55%) cases and proximal to the ischial tuberosity in only 1 out of 69 (1.45%) cases. The short head of the biceps femoris muscle was supplied distal to the ischial tuberosity in 62 out of 63 (98.41%) specimens and proximal to the ischial tuberosity in only 1 out of 63 (1.59%) specimens.

Table 4.2.2.1: Branches of the sciatic nerve to the hamstring muscles given proximal or distal to the ischial tuberosity (NB: Each branch treated as a separate entity)

Muscle	Total number of branches	Distal to ischial tuberosity(percentage)	Proximal to ischial tuberosity (percentage)
Long head of Biceps femoris	102	96 (94.22%)	6 (5.88%)
Semitendinosus	69	69 (100%)	
Semimembranosus	69	68 (98.55%)	1 (1.45%)
Short head of biceps femoris	63	62 (98.41%)	1 (1.59%)
Hamstring part of adductor magnus	64	64 (100%)	

4.2.3 Position of the branches to the hamstring muscles between the ischial tuberosity and the popliteal crease

The length of the thigh was found to be 34.4 +/- 2.02 cm. The first branches given off in the upper half of the thigh were supplying the long head of the biceps femoris and were located at a mean distance of 2.94+/-2.09cm below the ischial tuberosity. The most distal branches given off in the upper half of the thigh were supplying the semimembranosus muscle and were located at a mean distance of 13.28 +/- 2.02 cm below the ischial tuberosity (Table 4.2.3.1). Branches to the long head of the biceps femoris, semitendinosus, semimembranosus and the hamstring part of the adductor magnus muscles were found within zero to fifty percent of the way between the lowest point of the ischial tuberosity and the popliteal crease (Table 4.2.3.2). This overlapped with the upper part of the posterior compartment of the thigh.

Table 4.2.3.1: Vertical distance from the ischial tuberosity to the branches of the sciatic nerve distributed to the hamstring muscles

Muscle	Branch	Proximal or distal	Frequency	Vertical distance (cm)
Biceps femoris (long head)	1st Branch	Distal	57	2.94 +/- 2.09
		Proximal	6	2.72 +/- 2.68
	2nd Branch	Distal	33	8.06 +/- 2.82
	3rdBranch	Distal	6	11.45+/- 1.10
Semitendinosus	1st Branch	Distal	63	10.34+/- 3.66
	2nd Branch	Distal	6	11.48+/- 1.67
Semimembranosus	1st Branch	Distal	62	9.10 +/- 2.47
		Proximal	1	5.9
	2nd Branch	Distal	6	13.28+/- 2.02
Biceps Femoris (short head)	1stBranch	Distal	62	15.21 +/- 4.76
		Proximal	1	10.9
Hamstring part of adductor magnus	1stBranch	Distal	63	9.02 +/- 2.40
	2nd Branch	Distal	1	8.7

Table 4.2.3.2: Position of the muscular branches in reference to the distance between the ischial tuberosity and the popliteal crease

Muscle	Branch	Position
Long head of biceps femoris	First Branch	0 to 30%
	Second Branch	0 to 40%
	Third Branch	20 to 40%
Semitendinosus	First Branch	0 to 50%
	Second Branch	20 to 40%
Semimembranosus	First Branch	0 to 40%
	Second Branch	20 to 50%
Short head of biceps femoris	First Branch	10 to 80%
Hamstring part of adductor magnus	First Branch	0 to 40%
	Second Branch	20 to 30%

4.3 Termination of the sciatic nerve

The sciatic nerve terminated at a mean distance of 9.23+/-2.23 cm proximal to the transverse popliteal crease. These terminations occurred in the middle third of the posterior compartment of the thigh in 12 out of 62(19.35%) specimen. The nerve terminated in the lower third of the posterior compartment of the thigh in 50 out of 62(80.65%) cases (Table 4.3.1). The sciatic nerve divided in the pelvis in one specimen which was treated as an outlier during data analysis (Figure 4.3.1). Of the fifty (50) terminations that occurred in the lower third of the thigh, 41(82%) were inside the popliteal fossa while 9(18%) were outside the popliteal fossa (Table 4.3.2).

Table 4.3.1: Third of the thigh within which the sciatic nerve terminates

Third of thigh	Frequency (Percentage)
Upper	0
Middle	12(19.35%)
Lower	50(80.65%)
Total	62(100%)

Figure 4.3.1: Left gluteal region showing the sciatic nerve leaving the pelvis already divided. The common peroneal trunk can be seen passing through the belly of the piriformis muscle. (Green pins – piriformis muscle; White pin – common peroneal trunk; Red pin – Tibial trunk; Yellow pin – Lowest point of the Ischial tuberosity; Blue pin – The tip of the greater trochanter).

Table 4.3.2: Termination of the sciatic nerve relative to the popliteal fossa

Parameter	Frequency(Percentage)
Division of the sciatic nerve inside the popliteal fossa	41(65.08%)
Division of the sciatic nerve outside the popliteal fossa	22 (34.02%)
Total	63(100%)

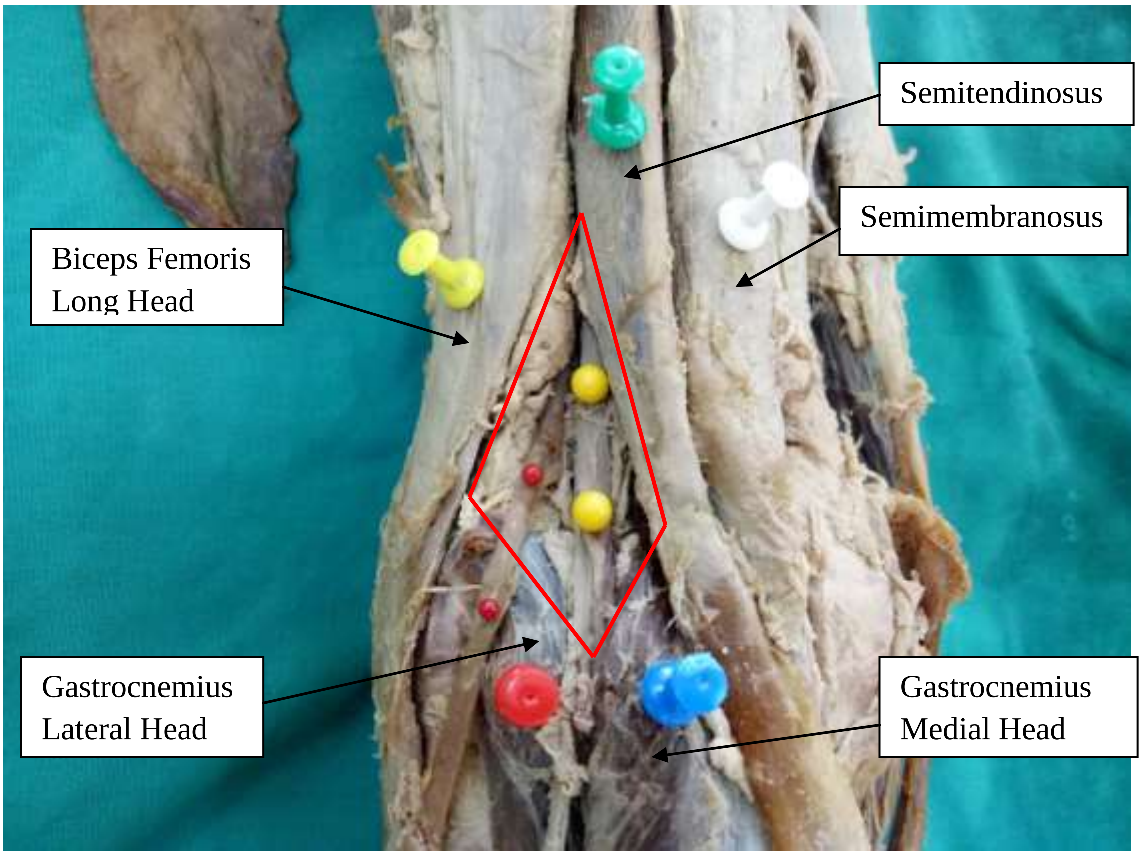

Figure 4.3.2: Specimen showing the terminal branches of the sciatic nerve inside the popliteal fossa (Red diamond shape with muscles forming its boundaries labelled) (Tibial trunk - Yellow beads; Common peroneal trunk – Red beads).

CHAPTER FIVE: DISCUSSION

5.1 The variations in the course of the sciatic nerve in relation to the greater trochanter of the femur and the ischial tuberosity

Placement of retractors during surgery are an established cause of neurovascular injuries and the common peroneal trunk of the sciatic nerve is among the nerves which are most commonly involved in this type of injuries(Wang et al., 2016). The sciatic nerve passed between the greater trochanter of the femur and the ischial tuberosity in all the extremities in this study and this concurs with the description by Standring S., (2016). Despite this common route for the nerve in several studies including this one, it is important for surgeons to note intra-operatively, after identifying the nerve that the other trunk could still be left out in cases where the nerve divided in the pelvis. Identifying a nerve of a smaller diameter intraoperatively should raise the suspicion that the nerve could have divided in the pelvis, as it was found in one specimen in this study and prompt the surgeon to look for the other trunk.

In this study, the distance between the greater trochanter of the femur and the ischialtuberosity measured 9.43+/-1.08 cm, which is not in agreement with the findings of a studyconducted by Guvencer et al., (2008) who reported 7.416+/-0.504 cm. The lateral edge of the sciatic nerve which corresponds to its common peronealtrunk measured 4.69+/-0.85 cm from the greater trochanter of the femur, which is in agreement with the findings of 4.28+/-0.44 cm reportedby Guvencer et al., (2008).The findings of this study also concur with those in a study conducted by Wang et al., (2016) who reported4.83+/-0.26 cmeven though in the latter study they conducted a retrospective review of hip MRI studies to establish the distance between the most lateral point of the greater trochanteric ridge and the lateral edge of the sciatic nerve. The distance between the sciatic nerve and the greater trochanter of the femur is very important intraoperatively as the posterior acetabular retractor has been noted by Shubert et al., (2015) to be the closest to the neurovascular bundle and could cause iatrogenic sciatic nerve injuries.

From the findings of this study, the distance between the ischial tuberosity and the medial edge of the sciatic nerve concurs with the findings from the cadaveric study by Guvencer et al., 2008 (3.61+/-2.02cm versus 2.2+/-0.42 cm).At least part of the sciatic nerve was found medial to the midpoint between the tip of the greater trochanter of the femur and the lowest point of the ischial tuberosity in 61 out of 63 (96.83%) limbs, which is in agreement with the findings by Guvencer et al., (2008) who found a mean distance from the greater trochanter of the femur to the lateral edge of the nerve greater than the distance midway between the two bony landmarks in all the extremities they studied. This finding is important for surgeons to consider in acetabular fractures involving the posterior wall or column where soft tissues have to be retracted medially to access the fracture site. The position of the sciatic nerve in relation to the greater trochanter of the femur and the ischial tuberosity is in agreement with the description of its surface marking that extends from just medial to the midpoint between the two bony landmarks to the apex of the popliteal fossa by Standring S., (2016).Despite the relevance of the findings of this study, the work had some limitations. The measurements were made on cadavers instead of fresh tissues intraoperatively. The cadavers were also positioned prone while making the measurements. Many orthopaedic surgeons prefer the lateral decubitus position for posterior approach to the hip joint.

5.2 Distribution of the sciatic nerve to the hamstring muscles

The long head of biceps femoris had one , two or three branches in 47.62%, 42.86% and 9.52% of specimens respectively contrary to the findings by Rha et al., 2016 (one nerve entry in 34.38% of specimens and two nerve entries in 65.62% of specimens). The findings were also contrary to the study by Woodley et al., (2005) who found a single muscle nerve branch in all the extremities they dissected. The branches emerged from the sciatic nerve distal to the ischial tuberosity in 94.22% of cases in this study, which is in agreement with the 83.33% of limbs dissected by Woodley et al., (2005).

Semitendinosus muscle was found to have one branch in 90.48% of specimens and two branches in 9.52% of specimens. This is contrary to the findings by Woodley et al., (2005) who found anatomical partitioning of the muscle into two distinct parts, each with its own muscle nerve branch in 66.67% of specimens. Nevertheless, all the branches to the semitendinosus muscle were given off distal to the ischial tuberosity in both studies. The findings of this study are also contrary to those of Rha et al., (2016) who reported two nerve entry points for semitendinosus muscle in all specimens.

Semimembranosus muscle in this study had one branch in 90.48% of extremities which is in agreement with the study by Rha et al., 2016. The muscle was innervated by two branches in 9.52% of the cases. These findings are also in agreement with the study by Woodley et al., (2005) who found one muscle nerve branch in 83.33% of specimens. The branches emerged distal to the ischial tuberosity in 98.55% of cases in this study which is in agreement with 100% in specimens dissected by Woodley et al.,(2005).

The short head of biceps femoris muscle was innervated by a single nerve muscle branch in this study and this is in agreement with Rha et al., (2016) who found a single nerve entry point in the muscle belly. Woodley et al., (2005) found two nerve branches to the same muscle in 83.33% of cases contrary to the findings of this study and the classical textbook description. Majority of branching occurred distal to the ischial tuberosity, 98.41% of specimens in this study, as in the study by Woodley et al.,(2005).

In the current study, the hamstring part of the adductor magnus muscle was innervated by one or two branches in 98.41% and 1.59% of cases respectively. The findings are in agreement with Woodley et al.,(2005) who found one branch in 83.33% of specimens. All the branches were given off distal to the ischial tuberosity in both studies.

To The Researcher's knowledge, other studies on the innervations of the hamstring muscles by the sciatic nerve did not include its distribution to the hamstring part of the adductor magnus muscle and as a result it was not possible to discuss the findings of this study in comparison to other studies. This indicates a gap that can be addressed by more studies not only on the innervation of the adductor magnus muscle but rather on the distribution of the sciatic nerve to all the hamstring muscles. The branches to the hamstring muscles are at a risk of sustaining iatrogenic injuries during dissections through the intermuscular planes which they traverse in order to reach the specific muscle bellies they supply. Such injuries can lead to complete dennervation of the short head of the biceps femoris muscle which has been shown to be supplied by a single nerve branch in this study and by Rha et al., (2016).

5.3 The termination of the sciatic nerve

The sciatic nerve did not divide in the upper third of the posterior compartment of the thigh in any of the extremities used in this study, which is contrary to the findings by Prakash et al.,(2010) (3.5%). Division of the sciatic nerve in the middle third of the thigh was encountered, in this study, in 12 out of 62 (19.35%) limbs in which the division of the nerve occurred outside the pelvis. This is in contrast to the division of the sciatic nerve in the middle third of the posterior compartment of the thigh in 10.4% of cases found by Ogeng'o et al., (2011). The nerve divided in the lower third of the thigh in 80.65% of the extremities in this study, which is in agreement with the findings by Shewale et al., (2013) (73.33% in the right lower limbs and 76.67 in the left lower limbs).

The incidence of sciatic nerve division in the popliteal fossa in this study was 65.08%, which is in agreement with a cadaveric study conducted by Ogeng'o et al., (201l) (67.1%) on black adult Kenyans and with other studies conducted by Okraszewska et al., (2002) (72.2%); and Grewal et al., (2016) (63.33%).Grewal et al., (2016)described the termination as occurring at the superior angle of the popliteal fossa (junction of the upper $2/3^{rd}$ and the lower $1/3^{rd}$ of the thigh) However, this is higher than the incidence found in one study locally by Berihu and Debeb., (2015) (5%) and another one in India by Prakash et al., (2010) (34.9%).A closer look at the study by Prakash et al., (2010) did not reveal anything in the methods that could explain the gross disparity between their results and other studies including this study.Studies conducted during routine undergraduate dissection classes by less experienced dissectors have an element that needs to be explored in trying to explain the gross difference in findings between studies conducted within one region of the world. The division of the sciatic nerve in the pelvis (one extremity), middle third of the posterior compartment of the thigh and in the popliteal fossa as shown in this study, can be explained by its embryological development and constitution as explained by Moore L.K., (20080 and Demiryurek et al., (2002).

In this study, the sciatic nerve terminated at a mean distance of 9.23+/-2.23 cm above the transverse popliteal crease, which is in agreement with the findings by Saleh et al., (2009) (83.9 +/- 22.7 and 78.85 +/-41.3 mm for male and female extremities respectively). The findings of this study are also in agreement with the study conducted by Kukiriza et al., (2010), who found the sciatic nerve to bifurcate at a mean vertical distance of 8.5+/-1.4 cm above the transverse popliteal crease.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

The variations in the course, distribution and termination point of the sciatic nerve were found to be similar to the findings in the previous studies conducted locally, regionally and globally.However, more branches to some of the hamstring muscles were found in this study compared to the few studies conducted globally. Sciatic nerve passes between the greater trochanter of the femur and the ischial tuberosity to reach the posterior compartment of the thigh. The nerve passes either through or medial to the midpoint between these two bony landmarks. The distribution of the nerve to the hamstring muscles occurred in the upper half of the way between the ischial tuberosity and the popliteal crease and this was within the upper half of the thigh. The sciatic nerve terminated in the lower third of the thigh with most of its divisions into the terminal branches taking place inside the popliteal fossa. Despite the common division of the nerve in the lower thigh, the termination can occur inside the pelvis before the nerve enters the posterior compartment of the thigh.

6.2 Recommendations

When placing retractors intra-operatively, mostly during the posterior approach to the hip and acetabulum, surgeons must be extra cautious at or medial to the midpoint between the greater trochanter of the femur and the ischial tuberosity to avoid iatrogenic injuries of the sciatic nerve. Identification of a much smaller sciatic nerve during surgery should raise the suspicion of a possible pelvic division of the nerve into its two main trunks.

Surgeons should keep to minimum dissections in through inter-muscular planes when operating in the upper half of the posterior compartment of the thigh to avoid denervation of the hamstring muscle bellies. Popliteal nerve blocks should be performed 7cm to 8 cm above the popliteal crease before thesciatic nerve divides into its two terminal branches.

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APPENDICES

Appendix 1: Data collection sheet

1. Date……………………………………………………………………………………

2. Identification code……………………………………………………………….

3. Side of the limb:Right……………………………..Left………………………….

4. ?? Gender: Male………………………………………Female……………………

5. Length of thigh ………………………………...cm

6. Relation of the sciatic nerve to the greater trochanter and the ischial tuberosity

Parameter	Distance in centimetres	Quadrant between ischial tuberosity and greater trochanter of the femur in which the nerve is found			
		Medial (1st)	2nd	3rd	Lateral (4th)
AC					
BD					
AB					

Parameters:
AC – The distance between the ischial tuberosity and the medial edge of the sciatic nerve.
BD – The distance between the apex of the greater trochanter and the lateral edge of the sciatic nerve.
AB – The distance between the apex of the greater trochanter and the ischial tuberosity.

7. Muscular branches to the Hamstringmuscles: their relation to the ischial tuberosity at origin, their vertical distance from the ischial tuberosity and their source

Muscle	Branches	Proximal to ischial tuberosity	Distal to ischial tuberosity	Vertical Distance from ischial tuberosity in cm	Source (sciatic, tibial or common Peroneal)
Biceps femoris long head	Branch 1				
	Branch 2				
	Branch 3				
Semitendinosus	Branch 1				
	Branch 2				
	Branch 3				
Semimembranosus	Branch 1				
	Branch 2				
Biceps femoris Short head	Branch 1				
	Branch 2				
Adductor Magnus	Branch 1				
	Branch 2				

8. Muscular branches to the hamstring muscles:

Muscle	Branches	Percentage of the way between the ischial tuberosity and the popliteal crease									
		10	20	30	40	50	60	70	80	90	100
Biceps femoris long head	Branch 1										
	Branch 2										
	Branch 3										
Semitendinosus	Branch 1										
	Branch 2										
	Branch 3										
Semimembranosus	Branch1										
	Branch2										
Biceps femoris short head	Branch1										
	Branch 2										
Adductor magnus	Branch 1										
	Branch 2										

9. Vertical distance from the popliteal crease to the point of division for the sciatic nerve;…………………cm

10. Point of termination for the sciatic nerve

Third of the thigh within which the sciatic nerve terminates			Popliteal fossa
Upper	Middle	Lower	

Appendix 2: Equipment and tools

1. Goggles
2. Disposable gloves
3. Dissecting kit
4. Calibrated Verniercallipers (accurate to 0.01mm)
5. Measuring tape and calibrated rulers
6. Stationery
7. Labellingaccessories
8. Digital camera

Appendix 3: Budget

Item	Unit cost	Quantity	Total
IREC fee	Ksh 2,000	01	Ksh 2,000
Assistant	Ksh 1000 per limb	50	Ksh50,000
Statistician	Ksh 50,000	01	Ksh 50,000
Laboratory Coat	Ksh 2000	02	Ksh4,000
Gloves	Ksh500	05	Ksh2,500
Goggles	Ksh 2500	02	Ksh 5,000
Dissection Kit	Ksh 2000	01	Ksh2,000
Surgical Blades	Ksh 10	100	Ksh 1,000
Disposable Mask	Ksh 25	100	Ksh 2,500
Digital Calliper	Ksh 4000	01	Ksh 4,000
Labels	Ksh 10	250	Ksh 2,500
Camera	Ksh 20,000	01	Ksh 20,000
Books, Pencils, Pens		01	Ksh 3,000
USB	Ksh 9,000	02	Ksh 18,000
A4 Printing Paper	Ksh 500	10	Ksh 5,000
Printing Costs	Ksh 15,000		Ksh 15,000
TOTAL			Ksh186,500

NB: The study will be financed by the Principal Investigator.

Appendix 4: Figures

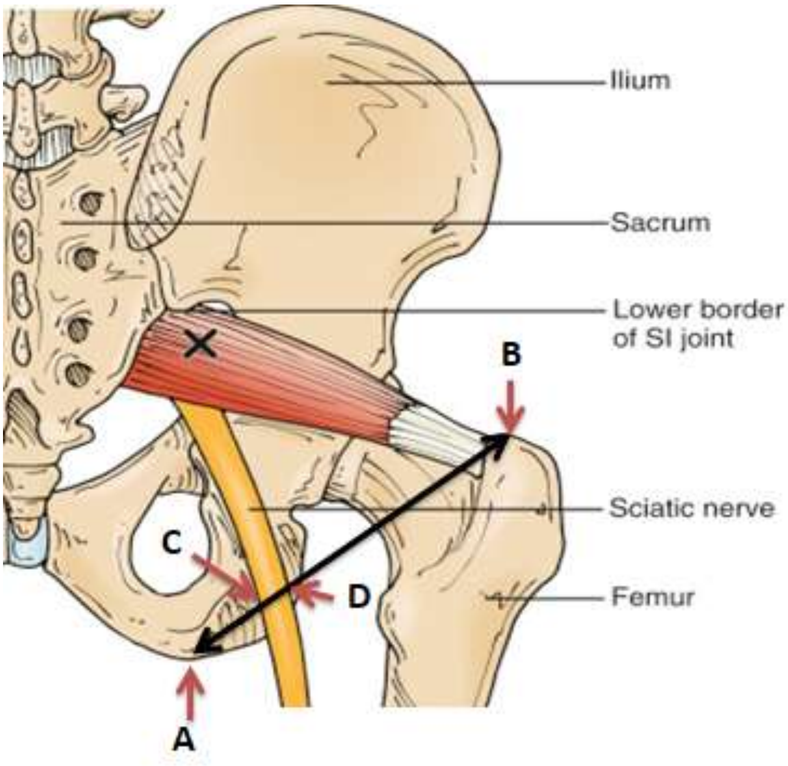

Figure 1: Posterior view of the pelvis showing the right gluteal region.

Parameters: AB (Black line) – The distance between the tip of the greater trochanter of the femur and the lowest point of the ischial tuberosity; AC – The distance between the lowest point of the ischial tuberosity and the medial edge of the sciatic nerve; BD – The distance between the tip of the greater trochanter and the lateral edge of the sciatic nerve (Adapted from Sciencedirect.com).

Appendix 5: Work plan

Activity	Deadline	Participants
Topic selection and Concept paper presentation to the department	April 2017	Researcher and supervisors
Proposal writing	July	Researcher and supervisors
IREC approval	November 2017	Researcher and supervisors
Data collection	June 2019	Researcher and supervisors
Data analysis	August 2019	Researcher and supervisors
Thesis write up	November 2019	Researcher and supervisors
Oral defense of thesis	June 2020	Researcher and supervisors

Appendix 6: IREC Approval

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471//2/3

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET

Reference: IREC/2017/242
Approval Number: 0002064

1st March, 2018

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
01 MAR 2018
APPROVED
P. O. Box 4606 - 30100 ELDORET

Dr. Kabelo Monthe,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

Dear Dr. Kabelo,

RE: FORMAL APPROVAL

The Institutional Research and Ethics Committee has reviewed your research proposal titled:-

"Variations in the Course, Distribution and Termination of the Sciatic Nerve in a Selected Adult Kenyan Population".

Your proposal has been granted a Formal Approval Number: ***FAN: IREC 2064*** on 1st March, 2018. You are therefore permitted to begin your investigations.

Note that this approval is for 1 year; it will thus expire on 28th February, 2019. If it is necessary to continue with this research beyond the expiry date, a request for continuation should be made in writing to IREC Secretariat two months prior to the expiry date.

You are required to submit progress report(s) regularly as dictated by your proposal. Furthermore, you must notify the Committee of any proposal change (s) or amendment (s), serious or unexpected outcomes related to the conduct of the study, or study termination for any reason. The Committee expects to receive a final report at the end of the study.

Sincerely,

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc	CEO - MTRH	Dean - SOP	Dean - SOM
	Principal - CHS	Dean - SON	Dean - SOD

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471//2/3

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

1st March, 2019

Reference: IREC/2017/242
Approval Number: 0002064

Dr. Kabelo Monthe,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
01 MAR 2019
APPROVED
P. O. Box 4606-30100 ELDORET

Dear Dr. Kabelo,

RE: CONTINUING APPROVAL

The Institutional Research and Ethics Committee has reviewed your request for continuing approval to your study titled:-

"Variations in the Course, Distribution and Termination of the Sciatic Nerve in a Selected Adult Kenyan Population".

Your proposal has been granted a Continuing Approval with effect from 1st March, 2019. You are therefore permitted to continue with your study.

Note that this approval is for 1 year; it will thus expire on 28th February, 2020. If it is necessary to continue with this research beyond the expiry date, a request for continuation should be made in writing to IREC Secretariat two months prior to the expiry date.

You are required to submit progress report(s) regularly as dictated by your proposal. Furthermore, you must notify the Committee of any proposal change (s) or amendment (s), serious or unexpected outcomes related to the conduct of the study, or study termination for any reason. The Committee expects to receive a final report at the end of the study.

Sincerely,

DR. S. NYABERA
DEPUTY-CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc:	CEO	-	MTRH
	Principal	-	CHS
	Dean	-	SOM
	Dean	-	SPH
	Dean	-	SOD

Appendix 7Hospital Approval

An ISO 9001:2015 Certified Hospital

MOI TEACHING AND REFERRAL HOSPITAL

Telephone :(+254)053-2033471/2/3/4
Mobile: 722-201277/0722-209795/0734-600461/0734-683361
Fax: 053-2061749
Email: ceo@mtrh.go.ke/directorsofficemtrh@gmail.com

Nandi Road
P.O. Box 3 – 30100
ELDORET, KENYA

Ref: ELD/MTRH/R&P/10/2/V.2/2010

23rd July, 2018

Dr. Kabelo Monthe,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

APPROVAL TO CONDUCT RESEARCH AT MTRH

Upon obtaining approval from the Institutional Research and Ethics Committee (IREC) to conduct your research proposal titled:-

"Variations in the Course, Distribution and Termination of the Sciatic Nerve in a Selected Adult Kenyan Population".

You are hereby permitted to commence your investigation at Moi Teaching and Referral Hospital.

DR. WILSON K. ARUASA, *MBS*
CHIEF EXECUTIVE OFFICER
MOI TEACHING AND REFERRAL HOSPITAL

cc - DCEO, (CS)
- Director of Nursing Services (DNS)
- HOD, HRISM