A Study on the bifurcation of sciatic nerve with its clinical significance

1Dr. Satyajit Sangram, 2Dr. Chiranjit Samanta, 3Dr. Mithu Paul, 4Dr. Susumna Biswas, 5Dr. Reshma Ghosh, 6Dr. Amitava Sarkar, 7Dr. Saktipada Pradhan, 8 Prof. (Dr.) Sudeshna Majumdar

1, 2, 3, 5, 6, 7 Junior Resident, Department of Anatomy, Nilratan Sircar Medical College, Kolkata – 700014, West Bengal, India
4 Demonstrator, Department of Anatomy, Nilratan Sircar Medical College, Kolkata – 700014, West Bengal, India.
8 Professor, Department of Anatomy, Nilratan Sircar Medical College, Kolkata -700014, West Bengal, India.

Corresponding author: Dr. Sudeshna Majumdar

Abstract:

Introduction: The sciatic nerve (SN) arises from the sacral plexus. It usually appears in the gluteal region below the piriformis muscle, passes along the back of the thigh and divides into tibial and the common fibular (peroneal) nerves near the apex of the popliteal fossa. But the point of bifurcation of the sciatic nerve is very much variable.

Methods: A study was conducted on the division of the sciatic nerve, in the Department of Anatomy, NRS Medical College, Kolkata, over two years, from December, 2012 to the November, 2014. 50 inferior extremities of 25 cadavers were dissected for this study. The dissections were done while teaching MBBS Students in the said department. The relevant structures were observed minutely and photographs were taken.

Observations: Among the fifty inferior extremities, in the sciatic nerve was found to be divided into tibial and common peroneal nerves in different levels (in the pelvis, gluteal region etc.)

Results: Out of fifty lower limbs, in forty one cases (82%) the sciatic nerve divided in the back of the thigh, near the apex of the popliteal fossa according to normal anatomy. In nine lower limbs (18% cases), the nerve divided high above, either in the sacral fossa (14% cases) or in the gluteal region (4% cases).

Conclusion: This high division of the sciatic nerve may result in nerve injury during deep intramuscular injections in the gluteal region, sciatica, piriformis syndrome etc. So this variation has importance in gross and clinical anatomy.

Key Words: Division of Sciatic Nerve, tibial nerve, common peroneal nerve, piriformis muscle

Introduction

Sciatic is a Greek word derived from ‘ischiadicus’. Sciatic nerve is also known as ischiadic nerve or ischiatic nerve, is a large nerve in humans and other animals. Sciatic nerve (SN) is the nerve of the posterior compartment of the thigh and via its major branches of all the compartments of leg and foot. It is typically 2cm. wide at its origin and is the thickest nerve in the human body with the root value: L4, 5, S1-3. Formed in the pelvis from the ventral rami of fourth lumbar to third sacral spinal nerves, the sciatic nerve leaves the pelvis via the greater sciatic foramen, below the piriformis and above the superior gemellus muscle, descends in the gluteal region between the greater trochanter and ischial tuberosities. Then it runs along the back of the thigh dividing into tibial and the common peroneal (fibular) nerves at a varying level proximal to the knee joint. The point of bifurcation of the sciatic nerve is very much variable. The common site is at the junction of the middle third and lower third of the back of the thigh, near the apex of the popliteal fossa...
(85-89% cases), but division may occur at any point above this and rarely may occur below it\textsuperscript{1, 2}. The tibial and common proneal nerves are structurally separate and only loosely held together within the sciatic nerve. Dorsal divisions of ventral rami of L\textsubscript{4-5}, S\textsubscript{1-2} form the common peroneal component and the ventral divisions of ventral rami of L\textsubscript{4-5}, S\textsubscript{1-3} form the tibial component of the sciatic nerve\textsuperscript{2}. Very often these two nerves arise separately from the sacral plexus and at that time, the common peroneal nerve may pass through the piriformis muscle and the tibial nerve below the muscle\textsuperscript{2}.

The piriformis is a flat muscle, pyramidal in shape, lying below the posterior margin of the gluteus medius. It arises from the front of the sacrum by three fleshy digitations and partly from the greater sciatic foramen and sacrotuberous ligament. The muscle comes out of the pelvis through the greater sciatic foramen and is inserted by a rounded tendon to the upper border of the greater trochanter of femur\textsuperscript{2}.

Piriformis syndrome is a controversial condition in which the anomalous relationship between piriformis and sciatic nerve is thought to cause pain in buttocks and along the course of the sciatic nerve\textsuperscript{2}. Piriformis syndrome may be caused by an entrapment of the sciatic nerve as it exits the greater sciatic notch in the gluteal region\textsuperscript{3,4,5}.

The high division of SN may give rise to complications during intramuscular injections, anaesthesia or surgery in the gluteal region\textsuperscript{3,4,6}. The sciatic nerve may be damaged in misplaced therapeutic injections in the gluteal region and the nerve is vulnerable in posterior dislocation of hip joint\textsuperscript{2}.

The present study was planned to describe the variations in the division of the sciatic nerve at different levels with the clinical implications.

**Materials and methods**

A study was undertaken to detect different variations in the bifurcation of sciatic nerve, in the Department of Anatomy, NRS Medical College, Kolkata, over two years, from December, 2012 to the November, 2014. 50 inferior extremities of 25 cadavers were dissected minutely for this study while teaching MBBS Students. The cadavers belonged to the adult age group (within 50 to 70 years age group); twenty male and five female cadavers were included in this study.

The relevant structures were observed carefully and photographs were taken. Variations were noted with calculation of their percentage.

**Observations**

Among the fifty inferior extremities, in twenty-five cadavers, the sciatic nerve was found to be divided into tibial and common peroneal nerves in different levels (in the pelvic cavity, gluteal region etc.). In forty one cases the sciatic nerve divided in the lower part of the back of the thigh, near the apex of the popliteal fossa, according to normal anatomy. So in 82% cases the nerve was found to be bifurcated in the posterior compartment of the thigh above the knee joint. This normal bifurcation of SN occurred in three female cadavers bilaterally (6 cases), in two unilaterally (2cases) and in fifteen male cadavers bilaterally (30 cases), and in three unilaterally (3 cases).

In nine lower limbs (18% cases), the sciatic nerve divided high above into tibial and common peroneal nerves, either in the sacral fossa or in the gluteal region. In two cadavers the sciatic nerve bifurcated in the pelvis bilaterally and in the inferior extremities of the other five cadavers, high division of the nerve was unilateral.
Among these nine cases, in seven of them (14%), the nerve bifurcated while in the pelvic cavity and tibial and common peroneal components emerged in the gluteal region below the lower border of piriformis separately. Four were right sided cases and three were left sided. Among these seven cases, there was a female cadaver with unilateral variation (1 case) and four male cadavers, where two of them had bilateral variation (4 cases) and two had unilateral variation (2 cases) of high division of SN in pelvis.

In the two other cadavers (4% cases), one male and one female, sciatic the nerve bifurcated in the gluteal region unilaterally. In both the cases, the nerve passed through the piriformis muscle dividing it into superior and inferior slips to appear in the gluteal region. Then after a short distance the sciatic nerve divided in each case into tibial and common peroneal nerves. In the female cadaver, the left lower limb and in the male cadaver, the right lower limb was concerned with this variation.

The photographs of eight cases with one normal bifurcation of the SN are presented in this article, the other case was similar to figure - 5.

| Table – 1 Different levels of bifurcation of the sciatic nerve with percentage: |
|---------------------------------|----------------|----------------|
| **Level of Bifurcation of SN**   | **Number of total cases with percentage** | **Bilateral** | **Unilateral** |
| Division of the sciatic nerve near the apex of the popliteal fossa | 41 (82%) cases. | In 3 female cadavers – 6 cases, In 15 male cadavers – 30 cases. Total 36 (72% cases). | In 2 female cadavers – 2 cases (one right and one left sided case). In 3 male cadavers – 3 cases (two left and one right sided case). Total 5 (10% cases). |
| Division of the sciatic nerve in the pelvis | 7 cases (14%) | In 2 male cadavers – 4 cases (8%). | In one female cadaver – 1 case (right sided). In 2 male cadavers – 2 cases (one right & one left). Total – 3 cases (6%). |
| Division of the sciatic nerve in gluteal region | 2 cases (4%) | Nil. | In one female cadaver – 1 case (left sided). In 1 male cadaver – 1 case (right sided). Total – 2 cases (4%). |
Figures

**Figure - 1:**
In a right sided lower limb of a female cadaver, the sciatic nerve (SN) passed between the two heads of the biceps femoris and divided into tibial and common peroneal nerves in the back of the knee joint.

**Index:** A – Sciatic nerve, B - Tibial nerve, C - Common Peroneal nerve, D- Hamstring group of muscles, E – Lateral head of Gastrocnemius, F – Biceps Femoris muscle.

**Figure - 3:**
In a left sided lower limb of a male cadaver, the sciatic nerve divided into tibial and common peroneal nerves in the pelvis and they emerged in the gluteal region below the piriformis muscle separately.

**Index:** A – Piriformis muscle, B – Gluteus maximus muscle, C - Tibial nerve, D - Common Peroneal nerve, E – Tibial and Common Peroneal nerves running side by side from the gluteal region to the back of the thigh, F – Gluteus medius muscle.
Figure – 4;
The two components of SN (Tibial and Common Peroneal nerves) running side by side in the back of the left thigh of a male cadaver.

Index: A- Tibial nerve, B- Common Peroneal nerve, C- Hamstring group of muscles.

Figure – 4
The two components of SN (Tibial and Common Peroneal nerves) running side by side in the back of the left thigh of a male cadaver. These two nerves seemed to have united as they ran very close to each other.

Index: A- Tibial nerve, B- Common Peroneal nerve, C- Biceps femoris muscle, D – Semitendinosus muscle.
**Figure - 5:** In a right sided lower limb of a male cadaver, the tibial and common peroneal nerves emerged in the gluteal region below the piriformis muscle separately as the sciatic nerve bifurcated in the pelvis.

**Index:**
- A – Tibial nerve
- B – Common Peroneal nerve
- C – Gluteus maximus muscle
- D – Piriformis muscle
- E – Tricipital tendons of gemellus superior, obturator internus, gemellus inferior
- F – Biceps femoris muscle
- G – Semitendinosus muscle

**Figure - 6:** In the right sided lower limb of a female cadaver, the sciatic nerve divided into tibial and common peroneal nerves in the pelvic cavity and emerged in the gluteal region below the piriformis separately to run in the back of the thigh passing deep to the origin of the long head of biceps femoris.

**Index:**
- A – Tibial nerve
- B – Common Peroneal nerve (both in the gluteal region and back of thigh)
- C – Piriformis muscle
- D – Gluteus maximus muscle
- E – Long head of Biceps Femoris muscle
- F – Semimembranosus muscle
Figure 7: Two divisions of the Sciatic Nerve (Tibial and Common Peroneal) emerged below the piriformis muscle in the gluteal region, passed to the back of the thigh deep to the origin of the Hamstring Muscles in the right lower limb of a male cadaver.

Index: A – Tibial nerve, B – Common Peroneal nerve (both in the gluteal region and back of thigh), C - Piriformis muscle, D - Gluteus maximus muscle, E – Inferior gluteal vessels and nerve, F - Long head of Biceps Femoris muscle, G – Semitendinosus muscle, H- Semimembranosus muscle.

Figure 8: In a left sided lower limb of a female cadaver, the Sciatic nerve emerged in the gluteal region through the divided piriformis and after a short distance divided into tibial and common peroneal nerves which ran in the back of the thigh.

Figure – 9: The sciatic nerve emerged between the two slips of the piriformis muscle in the right sided gluteal region and then it was divided into tibial and common peroneal nerves in the same region in a male cadaver.

Index: A - Sciatic Nerve, B - Tibial nerve, C - Common peroneal nerve, D - piriformis muscle with upper and lower slips, E – Gemellus superior, F - Gluteus medius muscle.

Discussion

A number of variations in the course and distribution of the sciatic nerve (SN) has been reported. Bifurcation into its two major divisions (common peroneal and tibial) may occur anywhere between the sacral plexus and the lower part of the thigh. The two terminal branches of the sciatic may arise directly from the sacral plexus. In 85-89% cases, the nerve divides into the terminal branches at the apex of the popliteal fossa; in the present study this percentage is 82%.

Smoll compiled the results of 18 previous studies and 6,062 cadavers to find that the prevalence of high division of sciatic nerve in cadavers was 16.9% and in surgical case series was 16.2%. In the present study, the prevalence of this variation (high division of SN) was 18%. According to Smoll again, the piriformis and SN variations have ranged from 1.5 – 3.58% in dissected human cadavers and in our study this variation is present in 4% cases.

Kirci et al in 1999, described a case with unilateral double piriformis and high division of sciatic nerve where the common peroneal nerve passed between the two parts of piriformis and the tibial nerve emerged under the lower border of inferior piriformis. In a case presented by Paval et al in 2008, bifurcation of the sciatic nerve in pelvis was found bilaterally in a 70 year old male cadaver. Common peroneal nerve pierced the piriformis dividing the muscle into upper and lower slips whereas the tibial nerve emerged below the lower slip of the piriformis on both sides. Khan et al (2011) found a case where on the left side common peroneal nerve passed between the two divisions of piriformis and tibial nerve passed below the inferior piriformis. In all these three cases, the sciatic nerve divided inside the pelvis before emerging in the gluteal region.

In 2013, Bhattacharya et al presented a case with double piriformis and division of the sciatic nerve in pelvis; the common peroneal nerve emerged between the two piriformis muscles, whereas the tibial nerve.
emerged below the lower piriformis on a left inferior extremity. On the right side sciatic nerve divided in the gluteal region after emerging from the lower border of piriformis.

In 2014, Saritha et al described few variations of sciatic nerve bifurcation in 4 cadavers from their study and their findings have similarities with those revealed in the present study like SN dividing in the pelvis. In 2014, Patil et al described an unique case where dorsal and ventral divisions of ventral rami of lower lumbar and sacral spinal nerves passed ventral and dorsal to the piriformis muscle respectively. These divisions joined each other below the piriformis muscle to form sciatic nerve. This low formation of sciatic nerve was observed in distal part of left gluteal region of a 50-year-old male cadaver. The sciatic nerve then passed caudally into back of thigh and divided into tibial and common peroneal nerves in the upper part of popliteal fossa. Such variations may lead to piriformis syndrome or non-discogenic sciatica.

Most of the text books of Anatomy, Surgery and Orthopaedics state that the sciatic nerve bifurcation levels are important in clinical and treatment aspects. This high division of sciatic nerve can cause nerve entrapment under other anatomic structures, resulting in non-discogenic sciatica, piriformis syndrome or coccydynia and muscle atrophy. This variation of sciatic nerve may result in nerve injury during deep intramuscular injections in the gluteal region, sciatica, piriformis syndrome, failed SN block in anesthesia or incomplete block of SN during popliteal block anesthesia, injury during posterior hip operations and other surgery in the gluteal region.

Low back pain, caused by a compression or irritation of the sciatic nerve is called sciatica. Sciatica may also be caused by directly due to a lumbar disc pressing on the sciatic nerve as it exits the intervertebral foramen in the lumbar spine. Investigations like CT scan, MRI, EMG, nerve conduction test are routinely done to detect nerve pathology.

In piriformis syndrome, the sciatic nerve can be entrapped between the gemellus superior and piriformis muscles. Another common site of entrapment is when the sciatic nerve or one of its branches pierces the piriformis muscle and this can occur in about 1% to 5% of all humans. In that case myosspasm and or contraction of the piriformis muscle itself can lead to pain along the buttock, back of the thigh to the knee, loss of sensation or numbness and tingling into the leg and sole of the foot. Piriformis syndrome is often misdiagnosed as sciatica due to similar symptoms.

Some workers consider piriformis syndrome to be a form of myofascial pain syndrome. A history of trauma may be present in approximately 50% of cases of the syndrome. The trauma is not usually sudden in onset and may occur several months before the initial symptoms treated in the orthopaedics or physical Medicine department along with rehabilitation. This syndrome can also be present among the athletes as a part of sport injury. It may also follow total hip replacement surgery. Complete medical history and physical examination are necessary for differential diagnosis of this syndrome.

The management of piriformis syndrome includes analgesic, muscle relaxants, injection of local anesthetic agents, steroid (like methylprednisolone) or botulinum toxin into the piriformis muscle; liquid anaesthetic agents can be injected to the area of sciatic nerve even. To avoid blind injection...
in the gluteal region, anatomical landmarks, electromyography or computed tomography (CT), fluoroscopic guidance will be helpful to identify the piriformis muscle and a nerve stimulator can be used for sciatic nerve identification. Surgery may be considered when the piriformis is involved in the sciatic nerve entrapment. The muscle may be thinned, divided or excised to be compensated with the surrounding muscles like obturator internus, gemelli, or quadratus femoris, as these muscles have common insertions like piriformis muscle. The knowledge and information about different variations of sciatic nerve bifurcation, will not only make the surgeons careful, but will also help them regarding proper planning for surgical intervention in the gluteal region or in the thigh.

Table – 2 Findings of the present study and the previous studies -

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<thead>
<tr>
<th>Variations of SN</th>
<th>Findings of the present study</th>
<th>Findings of the previous studies</th>
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<tr>
<td>Sciatic nerve (SN) bifurcated at the apex of the popliteal fossa</td>
<td>82% cases</td>
<td>85-89% cases&lt;sup&gt;1&lt;/sup&gt;</td>
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<tr>
<td>Sciatic nerve bifurcated high above</td>
<td>18% cases</td>
<td>16.9% cases in cadavers&lt;sup&gt;8&lt;/sup&gt; 16.2% surgical cases&lt;sup&gt;8&lt;/sup&gt;</td>
</tr>
<tr>
<td>Piriformis and SN variations</td>
<td>4% cases</td>
<td>1.5 – 3.58% cases&lt;sup&gt;8&lt;/sup&gt;</td>
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Conclusion
The variations of the bifurcation of sciatic nerve have clinical implications regarding deep intramuscular injections, popliteal block anaesthesia, hip surgery, practice of neurology etc. Moreover, this study will have a contribution in Sports Medicine and rehabilitation as the high level of division of the sciatic nerve and variation in the piriformis muscle may be the causes of soft tissue problems of hip, especially among the athletes. This study will also enhance our knowledge in Gross Anatomy and Clinical Anatomy.

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References


