Variations of the sciatic nerve and its relation with the piriformis muscle in South Indian population

Sushma R. Kotian, Anuja Sinha, Antony Sylvan D. Souza, Suhani Sumalatha

ABSTRACT

Objective: The sciatic nerve, a largest branch of the sacral plexus is prone to variations in its formation, course and branching pattern which may lead to multiple clinical complaints. The aim of the present study was to analyze the incidence of its variations in South Indian population. Methods: 60 gluteal regions were examined in 30 formalin fixed adult cadavers for the variations in the formation, termination of the sciatic nerve and its relationship with the piriformis muscle. Results: The sciatic nerve showed variations in its formation and as well as termination. High division of the sciatic nerve was the most commonly encountered variation (45%). The relationship of the sciatic nerve and its branches with the piriformis muscle was also variable. In majority of the cases (56.67%), the sciatic nerve and its branches were passing inferior to piriformis. Conclusion: Although the variations of the sciatic nerve are common and are already reported, the present study indicates some additional findings not reported previously and further stresses on its applied significance. These variations are important for surgeons, as this is an area of frequent surgical manipulation, nerve injury during deep intramuscular injections, sciatic nerve block etc. They may lead to in-advertent injury during operations, piriformis syndrome, non-discogenic sciatica, muscle atrophy, failure of sciatic nerve block and many other complications.

KEY WORDS: Common peroneal, piriformis, sciatic nerve, tibial, variations

INTRODUCTION

The sciatic nerve is the thickest nerve in the body and innervates the posterior compartment of the thigh and all compartments of the lower leg and foot. It is normally formed in the pelvis from the ventral rami of the L4-S3 spinal nerve roots and enters the lower limb via the greater sciatic foramen below the piriformis as a single nerve encompassed by a single epineural sheath [1]. Sciatic neuropathy is one of the most common neuropathies of the lower extremity and is a result of injuries to the sciatic nerve, leading to neurological deficits. Its long course makes it vulnerable to nerve injury from various causes [2].

There may be numerous variations both in the course and distribution of the nerve. The main variations concern the relationship of the nerve to piriformis. Sometimes it divides high, while still in pelvis, into its terminal branches that leave pelvis in a number of ways. High division of sciatic nerve is usually unilateral or bilateral, that leads to compression of nerve resulting in piriformis syndrome, incomplete block of sciatic nerve during popliteal block anesthesia and have a clinical importance in the etiology and pathogenesis of sciatica [3]. Therefore, these variations should be taken into account by clinicians planning interventions around the sciatic nerve and its division in the lower extremity. Hence, this study was undertaken on cadavers to study the incidence of variations in the formation and termination of the sciatic nerve in the south Indian population.

MATERIALS AND METHODS

The present cross sectional study was carried out in 60 formalin fixed lower limbs of 30 adult cadavers (20 males and 10 females) of age ranging from 45 to 70 years, in the department of Anatomy, Kasturba Medical College, Manipal. The study was done during medical students’ dissection classes.

The gluteal region, back of the thigh and popliteal fossa were exposed by meticulous dissection. The gluteus maximus muscles were cut in the middle and the halves freed and pulled away to expose the sciatic nerve and piriformis muscle. The biceps femoris muscle was also retracted to expose the course of the nerve in the back of the thigh. The nerve was then exposed in the popliteal fossa. In the three regions, the nerve was exposed by removal of fat and connective tissue.

The variations in the formation, level of bifurcation, relationship of the nerve and/or its divisions with the piriformis as well as the topographic relationship between the branches were examined and tabulated. The representative images of the variations were taken using Nikon Coolpix P510 digital camera.

RESULTS

The sciatic nerve showed variations in its formation as well as termination (Table 1, Figures 1-3). The division of the sciatic nerve in the popliteal fossa or in the posterior thigh region...
(Figure 1) was observed in 19 (31.67%) and 11 (18.33%) cases, respectively. High division of the sciatic nerve was most common and was encountered in 27 specimens (45%) (Figure 2). Low formation of the sciatic nerve was also observed in two cases (Figure 2). Additionally, non-formation of the sciatic nerve was observed in one case. In this case, a well-defined sciatic nerve was absent. Both tibial (TN) and common peroneal (CPN) components of the sciatic nerve were arising separately from the lumbosacral plexus. The anterior and posterior divisions of the lumbosacral plexus after providing the rest of the branches in the pelvis continued as the tibial and common peroneal nerves, respectively. This finding is rare and is seldom reported (Figure 3).

The relationship of the sciatic nerve or its divisions with the piriformis was also studied (Figure 2). In majority of the cases, the sciatic nerve was passing inferior to piriformis. It was observed that in 30 specimens (50%) of gluteal region, the sciatic nerve exits the pelvis as undivided nerve through the infra piriformis portion of greater sciatic foramen without any variation from normal course. Additionally, in four cases (6.67%) both tibial and common peroneal components of the sciatic nerve were passing separately inferior to piriformis. Observations in 26 cases (43.33%), demonstrated the common peroneal nerve passing through the piriformis and the tibial nerve inferior to it.
Table 1. Variations in the formation and termination of the sciatic nerve

<table>
<thead>
<tr>
<th>Variation</th>
<th>Percentage (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (division of the sciatic nerve in the popliteal fossa)</td>
<td>31.67% (19)</td>
</tr>
<tr>
<td>Division in the posterior thigh region</td>
<td>18.33% (11)</td>
</tr>
<tr>
<td>High division in the gluteal region</td>
<td>45% (27)</td>
</tr>
<tr>
<td>Low formation of the sciatic nerve with normal division in the popliteal fossa</td>
<td>3.33% (2)</td>
</tr>
<tr>
<td>Non-formation of the sciatic nerve</td>
<td>1.67% (1)</td>
</tr>
</tbody>
</table>

DISCUSSION

In the course of intrauterine development, the nerve contributing to the lower limb form two plexuses, i.e. lumbar and sacral, at the base of the limb bud [4]. Later, as the elements from each of these plexuses grow out into the limb, they are subdivided into dorsal and ventral components for dorsal and ventral musculature [4]. Sciatic nerve is formed when the large dorsal divisions (CPN) combines with the ventral divisions (TN). The two parts of the sciatic nerve develop separately in early embryonic stage and maintain their individual identity throughout their extent, even though joined together to form a single nerve trunk by a common connective tissue sheath [5]. Thus, during development, the two components of the sciatic nerve in the process of unification get wrapped around by a common connective tissue sheath.

Various studies have discussed the variations in the level of sciatic nerve division into tibial and common peroneal nerves [2-8]. The incidence of sciatic nerve division before its exit in the gluteal region in our study was 31.67% which was higher than the previous reports like Prakash et al. [2] (16.3%), Pokorny et al. [6] (20.9%), and Gabrielli et al. [9] (13.7%). Saleh et al. [10] studied the level of division of the sciatic nerve sheath into the tibial and common peroneal nerves above the knee in 30 cadaver specimens, and reported that the sciatic nerve divided at a distance of 50-180 mm above the popliteal fossa crease. Guvencer et al. [11] examined 50 gluteal regions in 25 cadavers and observed that in 52% of the cases, the sciatic nerve exited the pelvis as a whole nerve without any division, whereas in 48% of the cases, a high division of sciatic nerve was recorded.

Low formation of the sciatic nerve in the gluteal region is also reported [12]. These variations could be unilateral or bilateral. The current observation is in agreement with the previous studies. In addition, this study also reveals that the level where the common connective tissue wrapping for sciatic nerve commences is also variable, as indicated by the presence of separate components of the sciatic nerve up to the lower gluteal region. The common connective tissue sheath wrapping the two components of the sciatic nerve can also be completely absent thereby indicating the non-formation of the sciatic nerve (Table 1, Figure 1).

Acute sciatic neuropathies commonly result from hip arthroplasty, hip fracture or dislocation and intramuscular injections [13-16]. The extent of involvement and neurological deficits vary depending on the level of division of the sciatic nerve. A high division of the sciatic nerve into the tibial and common peroneal nerves can result in the escape of either the tibial or the common peroneal nerve from one of the aforementioned causes, which would finally result in a decrease in neurological deficits as compared to the low division of the sciatic nerve [14-16].

During sciatic nerve block, local anesthetic medication is in-filtered into the connective tissue sheath around the nerve. Complete sciatic nerve blockage will fail if the sciatic nerve is present as separately sheathed bundles up to the lower gluteal level. This condition, if present, might lead to failure of sciatic nerve blocks [17]. Further, high division of sciatic nerve may also lead to the failure of popliteal block anesthesia [2].

Figure 4. Relationship of the sciatic nerve (SN) with the piriformis muscle (PM). Left panel; undivided nerve (SN) below undivided muscle. Middle panel; divisions of the nerve below the undivided muscle. Right panel; divisions of the nerve (CPN & TN) between and below undivided muscle.
Previous anatomical studies demonstrated 15-30% variation in the relationship between the piriformis and the sciatic nerve [6]. The presence of variations in the relationship between the sciatic nerve and the piriformis may contribute to the occurrence of the piriformis syndrome. The piriformis syndrome is one of the causes of the non-discogenic sciatica. It arises secondary to the compression of the sciatic nerve by an abnormal piriformis [11].

Beaton and Anson classified variations of the piriformis and sciatic nerve in 120 specimens in 1937 [7], and in 240 specimens in 1938 [8]. Their classification, known as the Beaton and Anson classification, is as follows: type 1, undivided nerve below undivided muscle; type 2, divisions of nerve between and below undivided 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.

Pokorny et al [6], using 91 fresh cadavers, modified the Beaton and 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. Other authors have also reported the same and have classified the variations accordingly (6-8, 18-24) (Table 2).

The present study also agrees with the previous reports and affirms that the type 1 variation of Beaton and Anson classification is the commonest and was observed in 50% of the cases. Additionally, in the present study, both tibial and common peroneal components of the sciatic nerve were passing separately inferior to piriformis in 6.67% of the cases, i.e. divisions below the undivided muscle. Tibial and common peroneal nerves although are not wrapped with the same sheath, but the trace nerves are the same. In this reason, topographic localization isn’t different from sciatic nerve in gluteal region. Therefore, this finding could also be classified under type 1 of Beaton and Anson’s classification, thus making a total of 56.67% [7, 8].

Interestingly, in the present study, the divisions of nerve between and below undivided muscle (type 2 among the Beaton and Anson classification) was the second most common among the variations and was reported in 43.33% of the cases. This observation was of a relatively higher percentage compared to other studies [6-8, 18, 19, 21, 22]. A study by Chiba [20] had reported this type in 34% of the cases which is slightly related to our findings.

The topographic relationship between the sciatic nerve and piriformis muscle may be a possible etiology for the piriformis syndrome. The types of variations in them are therefore important and may reflect the clinical presentation of the piriformis syndrome. Involvement of the entire sciatic nerve or either of its components, i.e. tibial or common peroneal may cause different clinical symptoms [6, 17]. Anatomical variations in the formation and termination of the sciatic nerve and its relationship with the piriformis muscle are therefore very important. A thorough knowledge of these variations will enable the clinicians and surgeons to be careful while managing the different neuropathies or planning surgical interventions in this region.

### Table 2. Relationship between the sciatic nerve and the piriformis.

<table>
<thead>
<tr>
<th>Investigators</th>
<th>Type 1</th>
<th>Type 2</th>
<th>Type 3</th>
<th>Type 4</th>
<th>Type 5</th>
<th>Type 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaton and Anson (120 cadavers) [7]</td>
<td>84.2%</td>
<td>11.7%</td>
<td>3.3%</td>
<td>0.8%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Beaton (240 cadavers) [8]</td>
<td>90%</td>
<td>7.1%</td>
<td>2.1%</td>
<td>0.8%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ugrenovic et al (100 fetuses) [18]</td>
<td>96%</td>
<td>2.5%</td>
<td>1.5%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Moore and Dalley, (650 extremities) [19]</td>
<td>12.2%</td>
<td>0.5%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pokorny et al (91 cadavers) [6]</td>
<td>79.1%</td>
<td>14.3%</td>
<td>4.4%</td>
<td>2.2%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chiba (514 extremities) [20]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>34%</td>
</tr>
<tr>
<td>Machado et al (100 fetus extremities)</td>
<td>16%</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pecina (130 cadavers)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.15%</td>
</tr>
<tr>
<td>Ozaki et al [23]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Only one case</td>
</tr>
<tr>
<td>Sayson et al [24]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Only one case</td>
</tr>
<tr>
<td>Present study (60 extremities)</td>
<td>56.67%</td>
<td>43.33%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 34 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Kotian et al: Variations of the sciatic nerve
REFERENCES