

A CADAVERIC STUDY OF NORMAL AND VARIANT LEVELS OF DIVISION OF SCIATIC NERVE AND COUPLED ANOMALIES WITH CLINICAL APPLICATION IN SURGICAL INTERVENTIONS

Pooja Rani *¹, Sunita Kalra ².

*¹ Assistant Professor, Department of Anatomy, PGIMS, Rohtak, Haryana, India.

² Associate Professor, Department of Anatomy, UCMS & GTB Hospital, Delhi, India.

ABSTRACT

Background: Sciatic nerve, the thickest and the largest nerve of the body, is formed in the pelvis. After passing through the greater sciatic foramen, it enters the gluteal region, and subsequently the nerve passes on the back of thigh to reach the superior angle of popliteal fossa where it bifurcates into tibial and common fibular nerves. It usually divides into its terminal branches outside the pelvis; however it may rarely divide within the pelvis. In such cases, the tibial nerve and the common fibular nerve may leave the pelvis through different routes. The knowledge of different routes of exits of the sciatic nerve is of utmost importance for the surgeons and the interventionists dealing with this region as this is the site of innumerable surgical manipulations as well as nerve injuries during deep intramuscular injections in gluteal region, failed sciatic nerve block in anaesthesia and injury during posterior hip surgeries. These variations may result in non-discogenic sciatica because of the nerve compressions under other adjacent anatomic structures.

Purpose of the study: This study is an attempt to analyse the course, distribution and levels of the division of sciatic nerve into tibial nerve and common fibular nerve and their clinical implications.

Results: Out of the total 120 lower limbs studied, deviation from the usual described pattern was observed in four limbs. One cadaver showed bilateral variation while other two described unilateral disparity from the standard prototype.

Conclusion: This knowledge of variant anatomy of division and course of sciatic nerve and its terminal branches will not only assist surgeons to take care during interventions, but also facilitate to plan accordingly during various surgical procedures and management.

KEY WORDS: Sciatic Nerve Division, Clinical Implications, Surgical Interventions.

Address for Correspondence: Dr. Pooja Rani, Assistant Professor, Department of Anatomy, PGIMS, Rohtak, Haryana, India. Phone. +919910148979, +919034048979 and +919811370044
E-Mail: drpooja0912@yahoo.com and net31aug@yahoo.co.in

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BACKGROUND

The sciatic nerve is formed in the pelvis from the ventral rami of the fourth lumbar to third sacral spinal nerves, is typically 2 cm broad at its starting point and is the thickest nerve of the body. It enters the lower limb via the greater sciatic foramen below the piriformis muscle and

descends between the greater trochanter and ischial tuberosity. Then it passes along the back of the thigh and bifurcates into the tibial and common fibular nerves proximal to the knee usually at the apex of popliteal fossa. The sciatic nerve is the nerve of the posterior compartment of thigh and supplies via its branches, all the

compartments of leg in addition to the foot [1]. The level of division of sciatic nerve into its terminal branches at few different levels have been reported in some studies [2,3]. The premature division of sciatic nerve can occur in the pelvis, outside the pelvis, below the piriformis, or anywhere after that but rarely distal to the superior angle of popliteal fossa. The early division of sciatic nerve can be unilateral or bilateral. In some cases, when the division is high up in the pelvis, the common fibular branch may pass through the piriformis muscle leading to compression of nerve resulting in piriformis syndrome [4]. During popliteal block anaesthesia higher division of sciatic nerve may also be the reason for incomplete block of sciatic nerve and have a clinical significance in the etiology and pathogenesis of sciatica. The compression of this nerve causes paralysis of the respective muscles and plenty of sensory disturbances in the lower extremity.

MATERIALS AND METHODS

The study was conducted over a span of 6 years on sixty (120 sides) formalin fixed Indian cadavers of either sex (50 male, 10 female) which were being used for dissection purposes for teaching medical students at University College of Medical Sciences, Delhi, India. Dissection was carried out according to the dissection steps given in Cunningham's manual of practical anatomy and their gluteal regions were carefully dissected[5]. The gluteus maximus was elevated to explore the piriformis, the superior gemellus, the obturator internus, the inferior gemellus and the quadratus femoris. Following proper exposure in the pelvis, the sciatic nerve was traced till popliteal fossa. The location where the sciatic nerve exits the pelvis and the level of the sciatic nerve division and the course of the branches were all recorded and analyzed.

Fig. 3: A dissected specimen of right gluteal region of male cadaver showing sciatic nerve (SN) dividing into tibial nerve (TN) and common fibular nerve (CFN) over the quadrates femoris muscle (QF). Gluteus maximus muscle (GMx) muscle is seen supplied by ingerior gluteal nerve (IGN) formed by the two components marked by arrows. Gluteus medius muscle (GM) is also seen.

Fig. 1: A dissected specimen of left gluteal region of a male cadaver, showing the piriformis muscle (PM), cut and reflected superficial to which the sciatic nerve (SN) is seen dividing into its terminal branches, tibial nerve (TN) and common fibular nerve (CFN) which are traversing over superior gemelli (SG), obturator internus (OI), inferior gemelli and quadratus femoris (QF) muscle respectively. Inferior gluteal nerve (IGN) is seen arising from the sciatic nerve (SN) and is supplying the gluteus maximus muscle (GMx), which is cut and reflected. Superior and inferior gluteal arteries (SGA, IGA) are seen emerging above and below the piriformis muscle (PM) respectively. Gluteus medius muscle (GM) is also seen and posterior femoral cutaneous nerve (PFCN) is seen medial to tibial nerve.

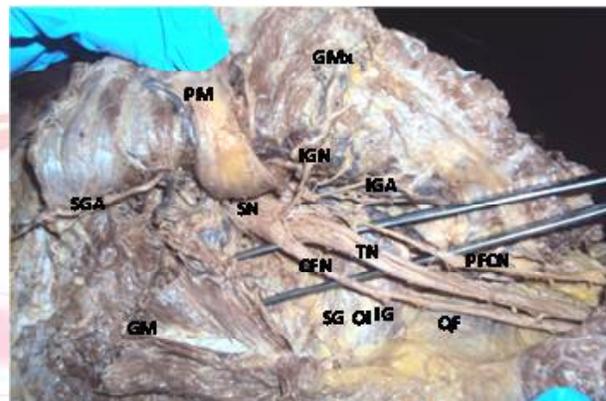
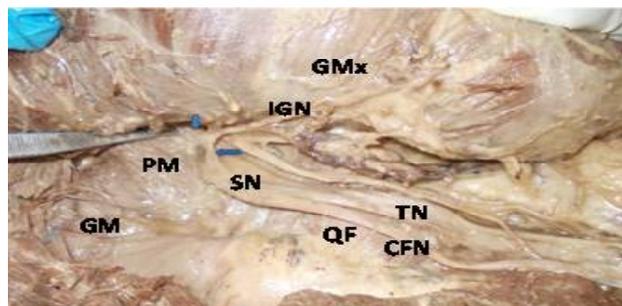
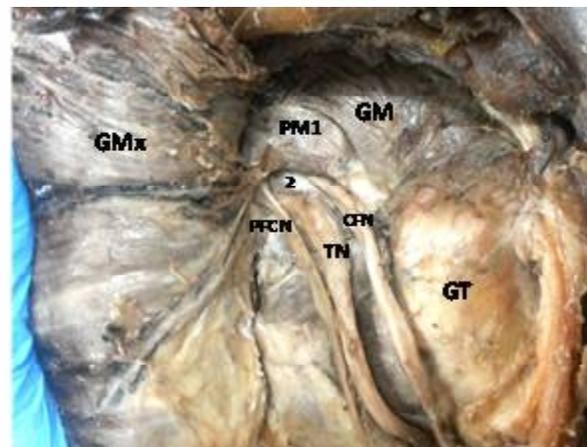


Fig. 2: A dissected left gluteal region of male cadaver, depicting Gluteus maximus (GMx) (reflected) under cover of which the two heads of piriformis muscle (PM1 and 2) are seen formed due to the passage of common fibular nerve (CFN) through the muscle. Tibial nerve (TN) is seen emerging below the (PM2) along with the posterior femoral cutaneous nerve (PFCN). Greater trochanter (GT) is also visualized.



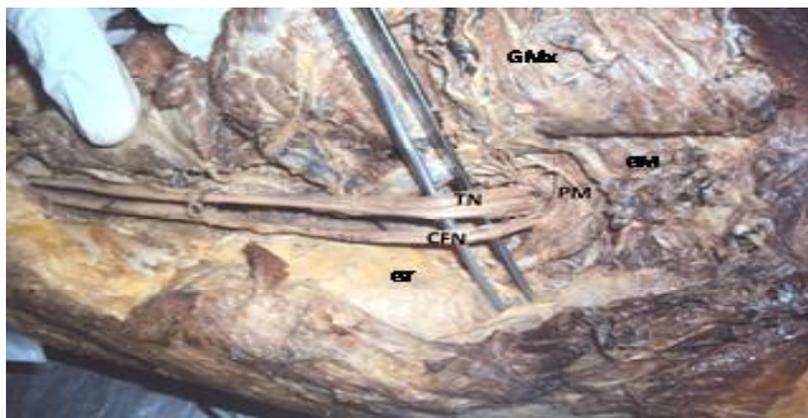


Fig. 4: A dissected specimen of right gluteal region, showing the piriformis muscle (PM) inferior to which the sciatic nerve (SN) is seen dividing into tibial nerve (TN) and common fibular nerve (CFN). Gluteus maximus (GMx) and Gluteus medius muscle (GM) is also seen. Greater trochanter (GT) is also visualised.

RESULTS

The total of 120 lower limbs were studied and it was found that in majority i.e. in 116 limbs the course and division of sciatic nerve was usual and did not show any variation in its mode of origin, deviation in its course, location of exit from pelvis and level of its bifurcation into terminal branches. However, in four limbs, we observed deviation from the usual described pattern. One cadaver showed bilateral variation while other two described unilateral disparity from the standard prototype.

In one 65 years old male cadaver on the left side, the origin of sciatic nerve was usual i.e. from the ventral rami of L4- S3 spinal nerves, it exit the pelvis through greater sciatic foramen to enter the gluteal region. There was premature and extraordinarily high division of sciatic nerve into its terminal branches. It divided into its branches just proximal to lower border of the piriformis muscle into tibial and common fibular nerve. Both the terminal branches emerged out below the piriformis muscle individually (Figure1). Later both of these nerves traversed the superior gemelli, obturator internus, inferior gemelli and quadratus femoris muscle and entered the posterior compartment of thigh. In the back of thigh also they travelled unconnectedly. Both the terminal branches followed the classic course and pattern of distribution in the thigh and leg. There was one more atypical variation on this left side of cadaver. The inferior gluteal nerve emerged from the sciatic nerve just before its division. The inferior gluteal nerve (L5-S2) as a rule is a direct branch from the sacral plexus. This inferior gluteal branch from the sciatic nerve supplied the gluteus maximus muscle from its deeper aspect.

In the same cadaver on the right side, sciatic nerve did not show any deviation in origin, level of termination into terminal branches or distribution from the classical established pattern.

In another male cadaver 75 years of age, the variant level of division of sciatic nerve was observed bilaterally. The sciatic nerve divided in the pelvis itself on the right side and emerged in the gluteal region as two separate terminal branches. The course taken by both the branches was also different. The tibial nerve emerged below the distal border of piriformis muscle whereas the common fibular branch pierced the piriformis, dividing the muscle into two heads and passed between these two heads of this muscle (Figure 2). The distal course of the two divisions was in accordance to the usual described pattern with no irregularity.

In the same cadaver on the left side, the sciatic nerve divided again prematurely. Here sciatic nerve after emerging out below the distal border of piriformis, travelled a short distance of 1 cm as a single trunk. Subsequently it divided superficial to quadratus femoris muscle into its terminal branches. On this side another interesting observation was recorded that two separate components contributed to formation of inferior gluteal nerve (Figure 3). Out of the two the larger component was customary from the lumbosacral plexus and the second was contributed by the undivided sciatic nerve itself. The two components joined together just below the piriformis muscle to form the inferior gluteal nerve, which ultimately supplied the gluteus maximus muscle from its deeper aspect.

Also, in another 70 year old female cadaver atypical higher division of the sciatic nerve on

the right side was established. The sciatic nerve after originating from ventral rami of L4-S3 spinal nerves emerged out from the greater sciatic foramen and passed deep to piriformis. It coursed habitually from the lower border of piriformis as a single trunk of sciatic nerve. Immediately, after emerging, the sciatic nerve separated into the tibial branch on medial side and common fibular branch on the lateral side (Figure 4). Then the two nerves traversed entirely independently in the posterior compartment of thigh and rest of the course and pattern of distribution was observed to be completely typical.

DISCUSSION

Grays anatomy describes the sciatic nerve 2cm broad at its origin and the broadest nerve of the body, as the continuation of the upper band of the sacral plexus. It leaves the pelvis via greater sciatic foramen below the piriformis muscle and descends between greater trochanter and ischial tuberosity, along the back of the thigh, dividing into the tibial and common fibular nerves, proximal to knee. Initially it is deep to the gluteus maximus muscle, then it crosses posterior to the obturator internus and both the gemelli, then on to the quadratus femoris. Along its course it is accompanied medially by the posterior femoral cutaneous nerve and the inferior gluteal artery. More distally it is behind the adductor magnus and is crossed posteriorly by the long head of biceps femoris muscle. It corresponds to a line from just medial to midpoint between the ischial tuberosity and greater trochanter to the apex of popliteal fossa where it divides into its terminal branches, the tibial nerve and the common fibular nerve [1].

The anatomical knowledge pertaining to diverse variations about the level of division of the sciatic nerve and the location where it leaves the pelvis is of utmost importance. In view of the fact that gluteal region is the area of numerous surgical manipulations, the variations in division of sciatic nerve in this region as described in the present study are extremely important for surgeons.

Division of sciatic nerve has been classified by many authors out of whom the most reliable classification is of Beaton & Anson.

They classified the variations of the piriformis and sciatic nerve in 120 specimens in 1937 and in 240 specimens in 1938 [2,6]. Their classification, known as the Beaton & 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

As per Beaton & Anson classification sciatic nerve in our study was found to be of type 1 in 98.33% of specimens, rest all types were not seen. In our study on 120 limbs, 3.3% cases showed high division of sciatic nerve. A totally different variation was observed in our study in which the piriformis muscle got divided into two separate heads to allow for the passage of common fibular nerve and the tibial nerve passed below the lower head.

Similar to our study Pokorny et al [7] using 91 fresh cadavers have modified the Beaton and Anson [6] classification and stated that the first variation namely the undivided nerve below undivided muscle was the most common type and seen in 79.1% of the specimens. Although they also reported maximum incidence of type 1 division but it is less than 98.33% as observed in the present study.

Machado et al [8] also performed a dissection in 100 fetuses and reported three types of variations -

A) Type I - The common fibular nerve penetrating the piriformis and tibial nerve passing under piriformis.

B) Type II - Common fibular nerve passing above piriformis and tibial nerve below piriformis.

C) Type III - Sciatic nerve piercing piriformis muscle.

According to this classification, we also observed Type 1 variation in our study but Type 2 and 3 were not seen in spite of a large number i.e. 120 adult limbs studied.

It is not uncommon for the piriformis muscle to

be pierced by some structures which are supposed to pass through the greater sciatic foramen [9,10]. It is usually seen that when sciatic nerve shows high branching pattern, that one of the branch pierces piriformis but does not completely divide it. Divided piriformis is said to be very significant, as common fibular nerve passing between two divisions is usually compressed and irritated resulting in the symptoms [4]. A clinical condition resulting from compression of the sciatic nerve or its components by the piriformis muscle is known as piriformis syndrome [11,12,13,14]. According to Papadopoulos et al., the incidence of piriformis syndrome is six times more frequent in females than in males [15]. In contrast to their observation, in the present study, we found the piriformis muscle divided by the common fibular nerve in the male cadaver. Chiba [16] studied the positional relationships between this muscle and the nerves located in the gluteal region in 13 different groups and found that the whole or a part of the common fibular nerve passed through the piriformis muscle in 34.04%. Ugrenovic et al [3] have found high division of the sciatic nerve in 27.5% of the specimens in a cadaveric study performed in 100 fetuses. In 96 out of 200 gluteal regions examined, the sciatic nerve was seen leaving the pelvis below piriformis. The common fibular nerve was seen passing below the piriformis in 2.5% of specimens and common fibular passing above piriformis and tibial nerve below piriformis in 1.5 % of cadavers. In our study on adult limbs, we found high division of sciatic nerve in only 3.3% cases. Also we didn't observe any such inconsistency as common fibular nerve passing above and tibial nerve below piriformis muscle as reported by Ugrenovic et al. This extremely significant difference in the results could be attributed to adult cadavers utilised in our report in contrast to the fetuses of unspecified age used in the studies by Ugrenovic et al and Machado et al which could have been due to the still ongoing process of development of adult patterns.

The passage of sciatic nerve or one of its branches through the piriformis has also been reported by Pecina [4] in 22% of 130 cadavers. Penetration of the piriformis by the sciatic nerve

itself was seen in 5% and piriformis piercing by common fibular nerve was seen in 17% specimens. In disparity to this, in our study there was no penetration of piriformis by the sciatic nerve but we found common fibular nerve passing through the piriformis muscle dividing it into two heads in one elderly male cadaver.

Lumbar disc herniation can compress the sciatic nerve and result in a clinical condition known as Sciatica. A common sign of lumbar disc herniation is reproduction of radicular leg pain in area of sciatic nerve distribution after performing straight leg raise test [17]. The variations in the course of the sciatic nerve as well as the surrounding musculature may affect the results of these nerve traction tests. The outcome of treatment procedures also can be altered due to these variations. In a retrospective study conducted by Suri et al., 81% of patients who sought conservative care for their leg pain associated with a lumbar disc herniation experienced resolution of symptoms in an average of 6 months. They suggested that patients who were refractory to treatment may warrant a re-examination, keeping in mind the many variations in anatomy, dermatomal patterns, and false positive/negatives of certain orthopaedic tests [18,19].

Embryological basis: The premature division of the sciatic nerve can be explained by studying the embryological development. The nerves contributing to the lower limb form two plexuses, lumbar and sacral at the base of the limb bud in the foetus. Later the components from both these plexuses get subdivided into dorsal and ventral components for the dorsal and ventral musculature. The large dorsal component of the sacral plexus (common fibular) and ventral component (tibial) move downwards close together to form the sciatic nerve [20]. Both the components of sciatic nerve develop separately in early embryonic life and maintain their individual identity throughout their extent, even though joined together by a common connective tissue sheath. Hence, based on their previously mentioned developmental formation, it is possible that the common fibular and the tibial divisions of the sciatic nerve separate from each other at different levels from their origins: within pelvis, in the gluteal region, the posterior

compartment of the thigh or the popliteal fossa [9].

During development the most primitive nerve fibres navigate considerable distances over perceptible virgin areas, regularly occupied by loose mesenchyme [21]. Axon guidance is considered to involve short-range, neighboring guidance signals and long-range diffusible signals, any of which can be either attractive and promoting, or repulsive and inhibitory for development. Once growth cones have enticed their target region, they then have to establish terminals and synapses. Apoptosis takes place if neurons are ineffective to attain sufficient amounts of specific neurotrophic factors during the synaptogenesis. Apoptosis of collaterals may endow with mature neuronal architecture. In surplus or a reduced amount of expression of one or multiple factors may be accountable for the variations in the formation, relation and distribution of the motor nerve fibers. These variations could also crop up from neurotrophic factors at the time of fusion of the branches of sacral plexus or sciatic nerve in the present study [22].

CONCLUSION

This knowledge of variant anatomy of division and course of sciatic nerve and its terminal branches will not only assist surgeons to take care during interventions, but also facilitate to plan accordingly during various surgical procedures and management. The premature divisions of the sciatic nerve may result in sciatica, nerve injuries during deep intramuscular injections in gluteal region, piriformis syndrome, failed sciatic nerve block in anesthesia and injury during posterior hip operations and innumerable other surgical interventions. Also when whole or a part of nerve passes through the piriformis muscle as seen in our study may result in compression of the nerve producing a clinical state, piriformis syndrome. This condition may resemble sciatica and can cause confusions while treating sciatica patients. So these types of variations should be kept in mind while dealing with not only sciatica due to inter-vertebral disc herniations but also as a differential diagnosis of nondiscogenic sciatica.

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Conflicts of Interests: None

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