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Original Research Article

DIFFERENT LEVELS OF BIFURCATION OF SCIATIC NERVE: A NOVEL CLASSIFICATION BASED ON A CADAVERIC STUDY IN INDIAN POPULATION

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ABSTRACT

Introduction: The Sciatic Nerve (SN) is the largest and thickest nerve in the body. It is composed of two nerves, the common peroneal (CPN) and the tibial (TN) which are bound together by a common sheath of connective tissue from their origin till the bifurcation at the superior angle of popliteal fossa. But this division may occur at any level above this point and rarely below it. These anatomical variations may contribute to clinical conditions such as piriformis syndrome, sciatica, coccygodynia and muscle atrophy.

Material and Methods: 30 Lower limbs of 15 cadavers (Male:Female -14:1) were dissected and examined to study the mode and level of bifurcation of SN.

Results: The highest incidence of SN bifurcation (63.3%) was observed at superior angle of popliteal fossa followed by division at junction of upper and middle 1/3rd of thigh in 20%, in the pelvis in 10% and in middle 1/3rd of thigh in 6.7%.

Conclusion: SN bifurcates terminally at different levels for which many classifications have been given. However there are certain over lapping and thus confusions amongst them. Therefore, a new classification termed as Grewal et al classification has been designed and advocated for future studies. It may prove more helpful for anatomists to categorise different levels of bifurcation of SN and for surgeons, orthopaedicians and anaesthetists performing surgeries in the region and giving SN blocks at different levels.

KEY WORDS: Bifurcation Of Sciatic Nerve, Variations, Tibial Nerve, Common Peroneal Nerve, Piriformis Muscle.

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INTRODUCTION

The Sciatic Nerve (SN) also known as ischiadic nerve is the largest and thickest nerve in the body. It is derived from all the nerves (L4-S3) contributing to the sacral plexus. It leaves the pelvis via the greater sciatic foramen(GSF) below piriformis and descends between greater trochanter and ischial tuberosity, along the back of thigh. It is actually two nerves, the common peroneal (CPN) and the tibial (TN). These are bound together by a common sheath of connective tissue from their origin till the bifurcation

at the superior angle of popliteal fossa (junction of upper 2/3rd and lower 1/3rd of thigh) in 85-90% of subjects. But this division may occur at any level above this point and rarely below it. In 10-15% of cases they separate at their origin. The anteromedial tibial component enters the buttock by passing below the piriformis. Sometimes posterolateral peroneal component may pass through or above the piriformis. At the apex of popliteal fossa the SN normally bifurcates (85-90%) into TN and CPN. This division may occur at any level above this point and rarely below it [1,2].

The anomalous relationship of SN with the piriformis may lead to SN entrapment and compression. This is known as piriformis syndrome which is a very common cause of buttock and leg pain. It may also occur in sportsmen who require excessive use of the gluteal muscles (eg-in ice skaters, cyclists & rock climbers). Trauma to the buttock is associated with hypertrophy and spasm of the piriformis muscle leading to nerve entrapment. In females, during pregnancy pressure from uterus may damage the nerve roots of SN [3].

The high division of SN may give rise to complications during intramuscular injections, anaesthesia or surgery in the gluteal region. The compression or irritation of SN causes sciatica. It presents as nerve pain, numbness, tingling, weakness and inability in walking depending upon the severity [4].

Thus it may contribute to clinical conditions such as piriformis syndrome, sciatica, coccygodynia and muscle atrophy. Awareness of such variations in point of bifurcation of sciatic nerve is important clinically and therapeutically to the surgeons, orthopedicians, anaesthetists and other medical practioners. Hence, the present study was undertaken to note the variations in bifurcation of SN, report their incidence and categorise the same.

MATERIALS AND METHODS

30 gluteal regions (15 cadavers) were examined after routine cadaveric dissection for the purpose of undergraduate teaching in the Department Of Anatomy, Government Medical College, Patiala. Out of these14 cadavers were male and 1 was female. The origin, course and bifurcation pattern of SN was noted in all the specimens. SN bifurcation at the superior angle (apex) of popliteal fossa was considered as normal.

Table 1 depicts the different levels of bifurcation of SN as seen in the present study.

Table 1: Levels of Bifurcation of SN.

Sr. no.	Level of Bifurcation	No. of limbs showing that level		
		Rt.	Left	Total [n(%)]
1	In the Pelvis	2	1	3 (10%)
a	Both CPN and TN infrapiriformis(IP)(Fig. 1)	1	1	2 (6.6%)
b	CPN Suprapiriformis (SP) and TN Infrapiriformis(IP) (Fig. 2)	1		1 (3.3%)
2	In upper 1/3rd of thigh	3	3	6 (20%)
3	In middle 1/3rd of thigh	1	1	2 (6.6%)
4	At Junction of Middle and Lower 1/3rd of thigh (Superior angle of Popliteal fossa)	9	10	19 (63.33%)

Fig. 1: Both TN & CPN are Infrapiriformis.

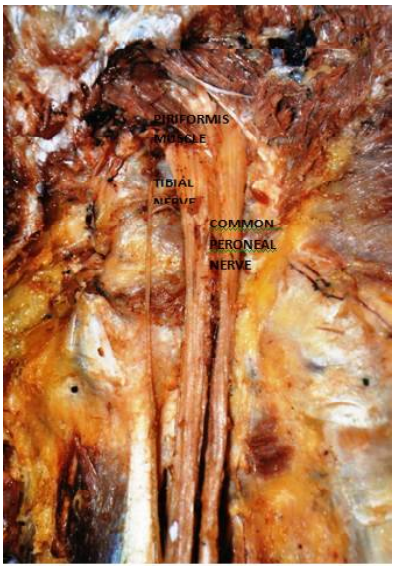

Fig. 2: CPN is Suprapiriformis & TN is Infrapiriformis.

Thus it is evident from Table 1, that in majority of limbs (63.33%) the SN bifurcated at superior angle of popliteal fossa i.e. junction of middle and lower 1/3rd of thigh. It was followed by the division in upper 1/3rd of thigh in 20%, in the pelvis in 10% and in the middle 1/3rd of thigh in 6.6%.

DISCUSSION

Different workers have given different types of classification of SN depending upon its level of bifurcation. Brooks et al (2011) [5] classified the level of division into 6 groups as follows:

Group A – Division of SN in Pelvis i.e. proximal to its exit to gluteal region

Group B – Division of SN in Gluteal region

Group C – Division of SN in Upper region of thigh

Group D – Division of SN in Middle region of thigh

Group E – Division of SN in Lower region of thigh

Group F – Division of SN in Popliteal fossa

In the same year Muthu Kumar et al (2011)[6] gave another classification in which one more type was added.

Type A1 – Undivided nerve emerges above the piriformis

Type A2 – Undivided nerve emerges through the piriformis

Type A3 – Undivided nerve emerges below the piriformis

Type B1 – Divided nerve emerges above the piriformis

Type B2 – Divided nerve emerges through the piriformis

Type B3 – Divided nerve emerges below the piriformis

Type C – Division of SN in Gluteal region

Type D – Division of SN in Upper thigh

Type E – Division of SN in Middle thigh

Type F – Division of SN in Lower thigh

Type G – Division of SN in Popliteal fossa

If we compare these 2 classifications it is seen that Group A of Brooks et al[5] classification corresponds to Type B of Muthu Kumar et al (2011)[6] classification, Group B with Type C, Group C with Type D, Group D with Type E, Group E with Type F and Group F with Type G. However Brooks et al (2011)[5] are silent about different types of emergence of undivided SN in relation to piriformis which are elaborated by Muthu Kumar et al (2011)[6] in their type A1-A3. Similarly they divided Type B into 3 subtypes depending upon relation of divided nerve with piriformis. If we ponder over Type A and Types C to G of Muthu Kumar et al [6] classification, it can be deduced that all the three subtypes of Type A may be further of any of Type C to G i.e. Type A may be further of any of types C to G, Type A2 may be of any of type C to G and similarly Type A3 may be of any of Types C to G. in other words Type C to G are further sub subtypes of subtypes A1, A2 and A3.

Relation of SN with piriformis at its exit from greater sciatic foramen have been classified in a more elaborate way by Beaton and Anson [7] as follows:

Type 1- Undivided SN below the undivided piriformis muscle. (i.e. the commonest presentation).

Type 2- The two divisions of the nerve through and below the piriformis muscle.

Type 3- The two divisions of the nerve above and below the piriformis muscle.

Type 4- Undivided nerve between the heads of piriformis.

Type 5 - The 2 divisions of the nerve between and above the heads of piriformis.

Type 6- Undivided nerve above the undivided muscle.

If we take a closer look at this classification, it is seen that Type 1, 4 and 6 refer to the undivided nerve emerging from the GSF while in Types 2, 3 and 5 the nerve divides in the pelvis. Thus this classification is primarily concerned with the relation of SN and piriformis at their exit from the GSF but it is silent about the level of division of SN distal to its exit from the pelvis. Similarly the classification of Brooks et al (2011)[5] is silent about the relation of SN and piriformis at their exit though they have elaborated on level of division after the exit. On the other hand, Muthu Kumar et al (2011) [6] have referred in their Type B about the relation of divided nerve with piriformis but not specified the site of exit of different divisions. Moreover, in these classifications the last two

types (Group E and F) of Brooks et al [5] and Type F and G of Muthu Kumar et al [6] overlap i.e. lower 1/3rd of thigh and popliteal fossa so they are confusing. Also both are silent about the division of the nerve at superior angle of popliteal fossa which is also the junction of middle and lower 1/3rd of thigh and is the commonest site of division [8].

All the drawbacks of the earlier classifications gave us an impetus to formulate a new classification which may take into account all these aspects and simultaneously refer to the relation of SN or its branches with the piriformis at their exit from the greater sciatic foramen(GSF) as well as level of division of SN after its exit from GSF if not already divided. So the following classification is proposed and coined as Grewal et al classification:

Group A- Division of SN in the pelvis and its two divisions (CPN and TN) emerging in different relations with piriformis.

Type 1: Both CPN and TN infrapiriformis

Type 2: CPN through piriformis and TN infrapiriformis (H" Type 2 of Beaton & Anson [7]).

Type 3: Both CPN and TN through piriformis.

Type 4: CPN suprapiriformis and TN infrapiriformis. (H" Type 3 of Beaton & Anson[7]).

Type 5: CPN suprapiriformis and TN through piriformis . (H" Type 5 of Beaton & Anson[7]).

The other combinations like TN suprapiriformis and CPN through/ below piriformis or TN through piriformis and CPN below piriformis are generally not seen or just hypothetical so presently not included in this classification. However, these may be included as types 6, 7 and 8 respectively.

Group B- Division of SN after its exit from GSF: This group may be first divided into three subgroups B1, B2 and B3 depending upon the relation of the main trunk of the SN with piriformis.

B1- SN emerging below Piriformis

B2-SN emerging through piriformis

B3- SN emerging above piriformis

Now all these subgroups may be classified into different types depending upon the level of division of SN after its exit from GSF.

Type 1- Division of SN in gluteal region i.e. between its exit from GSF and gluteal fold.

Type 2- Division at the junction of gluteal region and upper 1/3rd of thigh

Type 3- Division in the upper 1/3rd of the thigh

Type 4- Division at junction of upper and middle 1/3rd of thigh

Type 5- Division in the middle 1/3rd of thigh

Type 6- Division at the junction of middle and lower 1/3rd of thigh which is also the superior angle of popliteal fossa.

Type 7- Division in lower 1/3rd of thigh which is equivalent to upper half of popliteal fossa.

Thus in this newly proposed classification termed as Grewal et al classification, an attempt has been made to overcome all the shortcomings of the previous classifications.

Now according to this new classification the incidence of different types of exit of SN or its branches and their level of divisions after the exit as observed in the present study may be depicted in the Table no 2.

Table 2: Incidence of different types of SN division according to Grewal et al. classification.

Sr. no.	Group	Type	Incidence		
			Right	Left	Total
1	A	1	1	1	2 (6.6%)
2	A	4	1	-	1 (3.3%)
3	B1	3	3	3	6 (20%)
4	B1	5	1	1	2 (6.6%)
5	B1	6	9	10	19 (63.33%)

Thus the maximum incidence of 63.3% is seen in Group B1 Type 6 i.e. SN emerges as a single trunk below the piriformis (Group B1) and then divides at the level of superior angle of popliteal fossa at the junction of middle and lower 1/3rd of thigh (Type 6). Earlier different authors have given different incidence of level of division of SN that is compared with the present study in Table No. 3. As evident from table 3 our incidence of bifurcation of SN at superior angle of popliteal fossa is equivalent to that Ogeng'o et al[10]. On the other hand Sangram et al (2015)[4] and Saritha et al[12] found it 82% and 92% respectively which is more than our value of 63.3%. Parkash et al[9] and Kiros and Woldeyes[11] found SN bifurcating in lower 1/3rd of thigh in 40.7% and 8% respectively and in

Table 3: Showing Comparison of incidence of differet levels of division of SN.

Sr. No.	Authors (Race)	Level of Division of SN (Group/Type as per Grewal et al classification)								
		In the Pelvis			Gluteal region	Upper 1/3rd of thigh	Junction of upper & middle 1/3rd of thigh	Middle 1/3rd of thigh	Superior angle of popliteal fossa	Lower 1/3rd of thigh (upper ½ of popliteal fossa)
		Group A Type 1 (Both IP)	Group A Type 2	Group A Type 4 (CPN-SP & TN - IP)	Group B1 Type 1	GroupB1 Type 3	Group B1 Type 4	Group B1 Type 5	Group B1 Type 6	Group B1 Type 7
1	Prakash et al [9] (Indian)			17.40%	2.30%	3.50%	-	2.30%		40.7% + 34.9%*
2	Muthu Kumar et al[6] (Indian)	-		-	8%	14%	-	38%		32% +8%
3	Ogeng'o et al[10] (Kenyan)	9.80%		2.40%	2.40%	-	-	10.40%	67.10%	
4	Kiros & Woldeyes[11] (Ethiopian)			8%	4%	12%	-	4%		8%+ 64%**
5	Saritha et al [12] (Indian)	2%	2%	2%	2%	-	-	-	92%	
6	Desalegn & Tesfay [13]	2.80%		5.50%	92%					
7	Berihu and Debeb [14]	9%		2%						
8	Sangram et al [4] (Indian)	14%		-	4%	-	-		82%	-
9	Present Study (North Indian)	6.70%		3.30%	-	20%	-	6.70%	63.30%	

* Prakash et al [9] found bifurcation in lower 1/3rd of thigh in 40.7% and in popliteal fossa in 34.9% which are clubbed in the present classification to 75.6% because these 2 types are same as per present classification. (Group B1 Type 7)

** Kiros & Woldeyes [11] found bifurcation in lower 1/3rd of thigh in 8% and in popliteal fossa in 64% which are clubbed in the present classification to 72% because these 2 types are same as per present classification. (Group B1 Type 7).

the popliteal fossa in 34.9% and 64% respectively. In the present classification these two levels are taken as synonymous so their findings are clubbed to 75.6% and 72% respectively for the two studies under Group B1 Type 7 of present classification.

Leishiwon et al [15] conducted a similar study on 25 fetuses of 21-40 weeks of gestation. The highest incidence (86%) of SN division was found at the level of apex of the popliteal fossa which is equivalent to its superior angle and so it fits into Group B1 Type 6 of the present study. In 12% of their cases SN was found to divide in the pelvis. The TN was infrapiriformis whereas CPN pierced the piriformis muscle before emerging in gluteal region equivalent to Group A Type 2 of our classification. The lower incidence of bifurcation was observed in the gluteal region in 2% cases. No cases of bifurcation were observed in the upper and middle thirds of the back of thigh.

Ontogeny: During 5th week of intrauterine life the two nerve plexuses (lumbar and sacral) start developing at the base of lower limb bud**.** Later, these plexuses are subdivided into dorsal and ventral components for the dorsal and ventral musculature. SN is formed from the combination of dorsal divisions of L4,5 S1,2 (CPN) with the ventral divisions of L4,5 S 1,2,3(TN). These two components of SN develop separately in early embryonic stage and maintain their individual identity throughout their extent. During the process of unification as a single nerve trunk these two components are wrapped around by a common connective tissue sheath. The level where this connective tissue wrapping ceases and branching begins leads to variations in the bifurcation of SN [16,17].

Clinical implications: The anatomical variations of the SN have important clinical implications. These are reported in different races and populations with a variable frequency. The relationship between SN and piriformis muscle explains the anatomical basis of a neuromuscular condition known as piriformis muscle syndrome or non- discogenic sciatica . It is attributed to the compression of SN between piriformis and superior gamellus, if the nerve passes below the piriformis or between the two heads the muscle if the SN or its components pass through the piriformis. In any case it is characterized by sensitivity, motor and trophic disturbances in the region of distribution of trapped component of SN [18].

Piriformis syndrome is a peripheral neuritis of the sciatic nerve caused by an abnormal

condition of the piriformis muscle. It can masquerade other somatic dysfunctions like intervertebral discitis, lumbar radiculopathy, primary sacral dysfunction, sacroiliitis, sciatica and trochanteric bursitis. Etiologically, piriformis syndrome is of 2 types - primary and secondary. The primary piriformis syndrome has an anatomic cause such as a split piriformis muscle, split sciatic nerve or an anomalous sciatic nerve path. Secondary syndrome results from precipitating cause like macrotrauma, microtrauma, ischemic mass effect and local ischemia. Among patients with piriformis syndrome, 15% of cases have primary causes. The proper understanding of this syndrome requires knowledge of variations in relationship between SN and piriformis muscle [19].

Piriformis syndrome is also considered as a form of myofascial pain syndrome. In 50% cases history of trauma may be present. This syndrome can also present among athletes as a part of sports injury [4].

The SN and its components, are the most frequently injured nerves of the lower limb commonly injured during IM injection. Moreover it is also vulnerable to injury in posterior dislocation of hip joint and during total hip replacement surgery. Though complete palsy of SN is rare, it results in flail foot and severe difficulty in walking [20].

During popliteal block anaesthesia for surgeries of foot and ankle region the SN is approached 5-7 cm above the transverse popliteal crease. In such procedures, the high division of nerve leads to complete failure of SN block or an incomplete block of SN [21].

CONCLUSION

The SN presents significant variations concerning its topography and bifurcation into terminal branches. Most of the text books of Anatomy, orthopedics and surgery emphasize that the level of SN bifurcation are important clinically, diagnostically and therapeutically. The awareness of these levels is important for surgeons during various procedures like fractures, posterior dislocation of hip joint, hip joint replacement and hemiarthroplasty. These are also important during deep IM injections in the gluteal region and for anaesthetists during sciatic nerve blocks. A thorough knowledge of different variants will not only help surgeons to be careful, but also to plan accordingly during various surgical interventions over this region.

Previous researchers have classified the bifurcation of SN in different ways. But there are certain intra and inter- classification overlappings. Therefore, a new classification termed Grewal et al classification has been designed and advocated as it takes into account all the possible variants of SN bifurcation. Awareness of these will be of paramount importance for surgeons, orthopedicians, anasthetists, general medical practioners and nurses during various procedures over this region.

Conflicts of Interests: **None**

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