

Original Communication**VARIABILITIES IN ANATOMICAL ARRANGEMENT OF SACRAL PLEXUS ROOTS****Viktor Matejčík¹, Zora Haviarová^{2*}**¹*Department of Neurosurgery, Medical Faculty and University Hospital, Comenius University, Limbová 5, 833 05 Bratislava, Slovak Republic, Europe*²*Institute of Anatomy, Medical Faculty, Comenius University, Sasinkova 2, 813 72 Bratislava, Slovak Republic, Europe***RESUMEN**

Introducción. Las ramas del plexo sacro juegan un rol importante en la inervación motora y sensitiva del miembro inferior. En operaciones de la médula espinal observamos diversas variedades y nos motivó para iniciar este estudio dirigido a determinar la formación del plexo sacro desde la emergencia de cada raíz en los agujeros sacros hasta la formación de sus ramas terminales. **Material y método.** Se examinaron 100 plexos sacros en 50 cadáveres adultos con el propósito de determinar incidencia de las variaciones nerviosas. También consideramos el recorrido de sus ramas, sus anastomosis y grosor. Destacamos las particularidades de la inervación motora en el diagnóstico, además de la complejidad y variaciones anatómicas. **Resultados.** En general observamos 3 raíces sacras con la participación de S4 y el tronco lumbo-sacro de L4 y L5, y 4 nervios sacros. Habitualmente se observó un recorrido ascendente doble de la raíz S1, mientras que para las otras raíces la emergencia doble no fue común. El tronco lumbosacro se engrosó en 19 casos. La división muy alta del nervio ciático (en la pelvis menor) se observó en 2 casos. El nivel de ramificación de los otros nervios dependió del tipo de plexo. **Conclusión.** Nuestro estudio reveló variaciones relativamente frecuentes y variaciones anatómicas extraordinarias en la formación de las raíces nerviosas y la ramificación del plexo sacro. El conocimiento detallado de estas variaciones es útil para el propio diagnóstico y el tratamiento quirúrgico de las lesiones del plexo sacro y el dolor idiopático.

Palabras clave: *plexo sacro, raíces, variaciones.*

ABSTRACT

Introduction. Branches of sacral plexus play an important role in the motor and sensory innervation of the lower limb. Various variations observed during the spinal operations have motivated us to start the study

aimed on determination of the sacral plexus formation from its exit of particular roots from sacral foramina up to their formation into terminal branches. **Material and method.** One hundred sacral plexuses have been examined on 50 adult cadavers for a purpose to find out an incidence of its neural variations. We have considered also the course of their branches, the anatomoses and their thickness. We highlighted the motor innervation particularities in the relation to the diagnosis besides its anatomical complexity and variability. **Results.** Commonly were observed 3 sacral roots with the share of S4 and lumbosacral trunk of L4 and L5 and 4 sacral nerves. Doubled ascending course of S1 root was often observed, by the other sacral roots the doubled exit was not so frequent. Lumbosacral trunk was thickened in 19 cases. Very high division of the sciatic nerve (in the lesser pelvis) was observed in 2 cases. The branching off level of other nerves depended on the plexus type. **Conclusion.** Our study revealed a relatively frequent variabilities and described some extraordinary anatomical variations in the formation of nerve roots and branches of the sacral plexus. The detailed knowledge of these variabilities is useful for the proper diagnostics and surgical treatment of the sacral plexus injuries and unexplainable patient's complaints.

Key words: *sacral plexus, roots, variabilities.*

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INTRODUCTION

The sacral plexus is formed by the ventral branches of S1–S3 with a share of S4 and very important lumbosacral trunk formed of L4 and L5 roots. It extends above sacroiliac junction and consequently connects with the sacral nerves forming the sciatic nerve. The boundary root participating in the plexi formation is L4 root, which in some cases is largely involved in the lumbar plexus formation and in the sacral by others. Its participation in that or the other plexus helps to characterize the whole plexus as cranial prefixed with a share or caudal postfixed without a share of T12. It is necessary to emphasize that L4 root does not always play the role of boundary root; sometimes it is L5 root (Chin and Chew, 1997). After the available literature, we have met only with the orphan works devoted to these problems (Erbil et al, 1998; Chin and Chew, 1997; Hope et al, 1985; Iczl et al, 2005; Urbanowitz, 1981; Williams et al, 1995; Williams and Warwick, 1985; Weber, 1961).

MATERIALS AND METHOD

The study was realized on 50 (fifty) fresh cadavers without innate or detected abnormalities, tumour diseases, orthopaedic deformities or spinal operations. The ethics committee approval was obtained prior to the study. However, to the best of our literature search, we could not come across any study performed by the use of those reference structures or points. Therefore, we were not able to discuss our findings on the topography of the lumbosacral plexus and roots with the results of others. The lumbosacral plexi were dissected and clarified in all of the 50 cadavers; bilaterally from the anterior access following evisceration. The sacral nerves (the sciatic nerve, superior and inferior gluteal nerves, posterior cutaneous nerve of the thigh and pudendal nerves) were identified bilaterally. The nerves of the sacral plexus are located on the anterior area of piriformis muscle. The branches of the iliac vessels are in the vicinity of S1, S2 and S3 roots.

RESULTS

As with the upper extremity, the neural trunks of lower extremity in high cranial form also receive

more fascicles from above located nerves in comparison with low caudal form.

Number of S plexus root	Double root ascension	Plexiform root ascension
L5	8	4
S1	16	0
S2	8	0
S3	1	0
S4	0	0
S1 + S2	4	0
Total	37	4

Table 1. Variations in sacral plexus roots.

T12 and L1 roots are thicker in prefixed type. Then L4 root contributes more significantly to the sacral plexus and S3 and S4 roots are absent. If L4 root does not contribute to the sacral plexus or contributes only minimally, L5 root is thinner, S1–S3 roots are thicker and S4 root is present too. L5 root is the largest nerve contributing to sacral plexus in the postfixed type. When determining the type of plexus, the most appropriate was L4 root, eventually also L5 root. The prefixed type has occurred in 19 (nineteen) cases, the postfixed in 5 (five) cases. Variations in the area of plexi were most frequently on the level of neural root formation (Table 1). The intervertebral foramen is the narrowest on the level of L5/S1. It was usually completely filled with fifth lumbar root. The L4 root participated in the lumbosacral trunk formation in every case. The L5 root did not contribute to the lumbar plexus in any case. The branch from L4 root to L5 root was thicker as L5 root itself in 11 (eleven) cases. Thin connection of L4 root with L5 root was present in majority of cases. Thick lumbosacral trunk was present in 19 (nineteen) cases (Fig. 1). The participation of L4 root in the sacral plexus formation was observed in every case. Absence of junction between the plexi was not observed in any case. In cases of prefixed plexus—thick lumbosacral trunk in sacral plexus formation, only S1 and S2 roots were present and nerves of sacral plexus ascended from L5, S1 and S2 roots. For the postfixed type, the lumbosacral trunk was thin, S1, S2 roots were thicker. The S3 and S4 roots were present too. For other cases, truncus lumbosacralis and S1, S2, S3 roots were present. Changes in the sacral plexus on the level of neural roots were observed in 41 (forty-one) times. The double exit

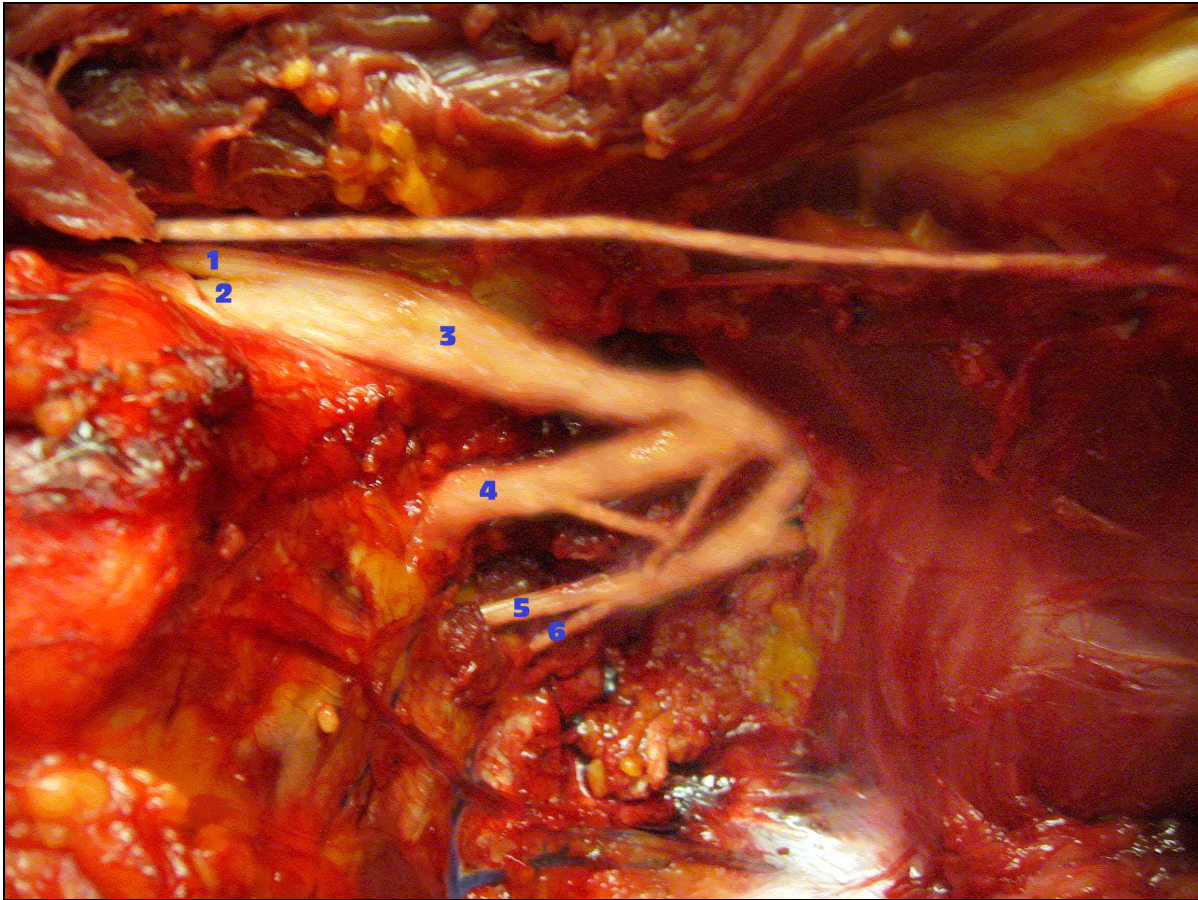


Figure 1. Thick truncus lumbosacralis, *left side*, front view, in craniocaudal direction, from *right to left*: thin S1 and S2 roots, a branch from L4 root (1), L5 root (2), truncus lumbosacralis (3), S1 root (4), S2 root (5), S3 root (6).

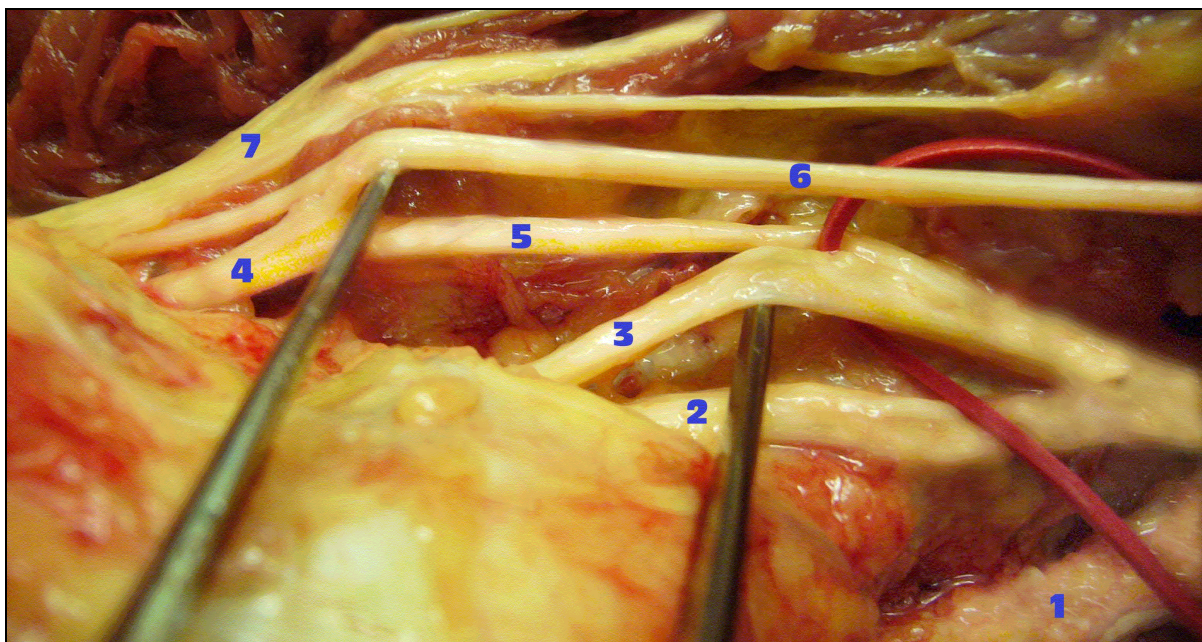


Figure 2. Double exit of L5 root, *left side*, front view, in craniocaudal direction, from *right to left*: S1 root (1), L5 root (2, 3), L4 root (4), a branch from L4 root to L5 root (5), n. obturatorius (6), n. femoralis (7).

of L5 root (Fig. 2) was present in 8 (eight) cases. Plexiform exit of the L5 root was observed in 4 (four) cases (Fig. 3). Double exit of S1 root following their exit from sacral foramina was seen in 16 (sixteen) times, S2 8 (eight) times and S3 once, S1 + S2 roots simultaneously in 4 (four) times. S1, S2 and S3 roots were branched in the various distance following its exit from the sacral foramina in 15 (fifteen) cases. The sciatic nerve

was branched into tibial and peroneal portion already in the minor pelvis in 2 (two) cases. Nervus cutaneus femoris posterior leaves S1 root and takes shares of S2 and S3 roots. Nervus pudendus was formed depending on the plexus type from S2 and S3 roots. If main trunk of nervus pudendus leaves S3 root, it takes a share of S2 root.

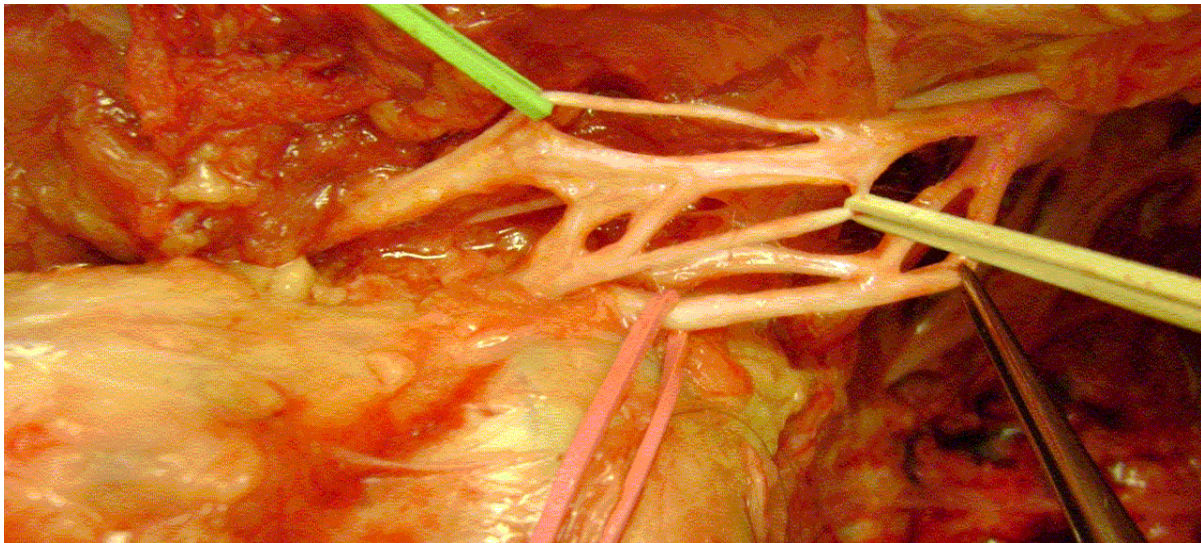


Figure 3. Plexiform exit of L5 root, *left* side, front view, in craniocaudal direction, from *right* to *left*

DISCUSSION

The lumbosacral plexus is an analogue of brachial one. Differences in lumbosacral plexus formation are demonstrated in that manner that segmental participation of certain nerves, as well as their participation in tissue innervation may be changed, as in brachial one on the periphery. Nevertheless, interest in details of both plexi formation is not the same. It is because injuries as well as variations of lumbosacral plexus formation are less frequent in comparison with brachial one. Indications for reconstructive operations of lumbosacral plexus are exceedingly rare. There are a lot of variations of standard pattern related to innervation from lumbosacral plexus, but innervation from the first two sacral nerves is quite constant. S2 root also innervates glutei and musculus biceps femoris. The superior gluteal nerve innervates gluteus medius muscle (so-called "deltoid" of coxal joint), gluteus minimus muscle and extends forward, innervating

tensor fasciae latae muscle, while S3 root usually innervates flexors of big toe and only rarely other muscles on the lower extremity. S4 root innervates no muscles on the lower extremity. The L4 root contributes to lumbar and sacral plexi and therefore it is called branched or furcate "furcal nerve". With the exception of L4 root, in the literature we did not find any cases of root duplication or root fragmentation of lumbosacral plexus that could constitute real operational pitfalls for neurosurgeon and anaesthetist during the regional anaesthesia.

Following Bergman et al. (1988), both plexi—lumbar and sacral—are connected with furcal nerve in 91.8%. The connection was not found in 7.4%. Iczki et al. (2005) has seen only one case of furcal nerve and had not observed any variation of the connection between lumbar and sacral plexus. Erbil et al. (1998) has described an occurrence of prefixed type on one side and postfixed type on the other in the casuistics. These variations are very rare. Lumbar and sacral plexi play an important role in the regional

anaesthesia, particularly in sacroiliac and pelvic surgery. For its surgical treatment is important to put attention to vessel structures. Inferior gluteal artery is the branch from the internal iliac artery and leads into numerous branches, damaging of which is necessary to have in mind in operation, because they may be retracted into pelvis and may bleed. The components of lumbosacral plexus spread on the lower extremity, similarly as the brachial plexus spread on the upper extremity. The sacral nerves spread similarly as the nerves from posterior fascicle of brachial plexus. Many variations of lumbosacral plexus formation are a source of diagnostic confusions besides atypical clinical and electromyographic findings. It is important to understand what neural functions are transferred in particular parts of the plexus. It is also necessary to bear in mind that muscle innervation may change independently on number of the root entering the plexus due to presence of various connections between plexus roots. Neural roots in prefixed type take more filaments from the above located spinal nerves. The injuries of highly located neural roots or nerves are accompanied with much more prevalent lesion on the periphery in comparison with the same injuries in postfixed type. The S3 root in postfixed type may have many filaments normally born by S2 root and the share of S4 may be greater. It is supposed that the deviations in lumbosacral plexus formation are caused by a deviation from normal development process, during the fourth week of foetal development (Marieb and Mallat, 2005; O'Rahilly et al, 1990). Anatomical organization of lumbosacral plexus has its particularities. Neuroanatomical variations are the cause of unexpected radicular patterns. It is necessary to take into account individual specific variants in formation of clinical picture, its diagnostics and surgical treatment. Injuries may be prevented or lessened to a minimum level through the detailed knowledge of the topographic features and variations. Understanding of the structure and course of sacral plexus is important during all interventions to these regions due to the potential damage on the nerve itself. Its importance raises by the

introduction of the new procedures in spinal anaesthesia, spinal operations in spondylosurgery, endoscopic operations in retroperitoneal approach in laser discectomy, ozonotherapy, etc.

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