Acta Neurochir (2005) [Suppl] 92: 53–59

Printed in Austria

Microsurgical treatment of lumbosacral plexus injuries

A. Alexandre, L. Corò, and **A. Azuelos**

EU.N.I. European Neurosurgical Institute, Treviso, Italy

Summary

Surgical treatment of lumbar and sacral plexus lesions is very rarely reported in the literature.

The incidence of the involvement of these nervous structures in traumatic lesions of different etiology is probably much higher than believed, and surgical treatment should be taken into consideration more often.

In this paper the experience derived from the surgical treatment of 15 cases is reported. Different surgical approaches have been employed according to ethiology, to level of nerve lesion and concomitant lesions of other organs.

Patients who suffered a lesion in the lumbar or sacral plexus may have a very severe problem with deambulation since the leg may not be stable or may be unable to withstand the weight of the body. Pain syndrome in these patients may be a very severe obstacle to rehabilitation programs and to deambulation and everyday activity.

Microsurgical nerve treatment in the retroperitoneal space is demanding both for the surgeon and for the patient but neurolysis and grafting procedures are possible also in this area. The resulting improvement of motor performance and the relief of pain are strong arguments in favor of this choice. Muscles benefitting most from surgery are the gluteal and femural muscles; more distant muscles, and particularly the anterior tibial nerve dependent muscles will gain minimal benefit from surgery. The relief from pain is relevant in all cases.

Keywords: Lumbosacral plexus; peripheral nerve surgery; nerve injuries; microsurgery.

Introduction

Injuries to lumbar and sacral plexuses are very rarely reported in the literature. Their incidence is estimated very low [25, 29]. Probably incidence of this pathology is underestimated which may be due to the difficulty of such diagnosis and possibly also the lacking awareness that such a lesion may exist.

Analogous nerve lesions in the upper limb are well understood and well approached all over the world thanks to an enormous number of anatomical, experimental and clinical studies. Not so much attention has been payed to lumbosacral plexus injuries, for reasons discussed in this paper.

Such patients are often simultaneously affected by damage to several soft, parenchymatous [10, 13, 20, 21, 29, 30] and bony tissues [1, 2, 10, 12, 15, 19, 30, 31, 32], and this may makes neurological diagnosis difficult. This is particularly true for patients who in emergency receive treatment by general, urological, or obstetrical surgeons. In other cases diagnosis may be hindered by superimposing symptoms due to pathology of other organs, or by interposition of a long time span between injury and specialised clinical examination. The long time interval may be accompained by a sketchy clinical history and by incomplete or superficial surgical reports. A different case are iatrogenic nerve lesions which may long remain misunderstood or underestimated.

Nerve surgery in the abdominal retroperitoneal area is rarely performed [3, 5, 6, 11, 22, 23, 26] both because of the aforementioned problems and because of technical difficulties due to deep location of the nerve structures to be reached by a laborious approach with the risk of haemorrhage and infection. For the neurosurgeon this is an unusual anatomical area.

In the literature surgical treatment is reported to have been done in small series of patients: 14 cases have been published in the last years [5, 6, 11, 25]. Recently Kline and Hudson [22] presented their wide experience with a first relevant series of surgically treated cases.

In this paper a revision of the personal casistic is given, with some comments on surgical approaches.

Anatomical considerations

A careful anatomical study has been performed on 14 adult cadavers in order to collect data on the microsurgical anatomy of the region and to verify surgical possibilities. Lumbosacral plexus is composed of nerve roots L1 to S2. As for brachial plexus, nerve roots also in this anatomical area located anteriorly provide flexor functions, posterior ones extensor functions [8, 14, 23, 33].

Lumbar and sacral plexuses are to be considered separately because of the completely different destiny of their terminal branches and because of the differences in topographical anatomy which entail different surgical approaches.

The lumbar plexus originates from the spinal roots L2, L3 and L4 and receives contributions from L1 and L5 roots.

It is located in the corner between the vertebral bodies and lateral apophyses. It is covered by the ascending iliac and cava veins and by the aorta and common iliac arteries on the right side and by iliac arterial and venous plexuses on the left. Posterior to these structures is the psoas muscle which covers entirely the plexus. In the space between the psoas muscle and the spine, together with the plexus, lumbar arteries and lumbar and azygos veins which form the ascending lumbar vein are met.

While most cranial nerve roots and trunks have a fairly horizontal direction, the more caudal ones are obliquely oriented and in the plexus are located posterior to the more cranial ones.

Several terminal branches take origin from the lumbar plexus: iliohypogastric, ilioingiunalis nerves, nervous branches to psoas and ileous muscles, genitofemoralis, lateral femorocutaneous, obturatorious, obturatorius accessorius, and femoral nerves.

Three of these nerves, namely ileohypogastricus and ileoinguinalis proximally and femorocutaneous more distally, emerge from the lateral border of psoas muscle, and run on the posterolateral muscular wall of abdomen. Genitofemoralis nerve on the contrary emerges from the anterior surface of psoas muscle, in a virtual septum between minor and major psoas and runs subfascial on this muscle. Obturator nerves remain in a hidden position, behind psoas belly, running parallel to the lumbosacral trunk.

Thus the subserved muscles are: abdominal, psoas, iliac, pectineus, sartorius, quadriceps femoris, and adductors of the thigh.

The sacral plexus originates from the spinal roots L5-S1-S2 and S3; some fascicles coming from L4 contribute to this plexus, joining L5.

Sacral plexus lies on the sacroiliac junction, and on the piriformis muscle; it is located medially to the psoas muscle, between the latter and the column.

Hypogastric artery intermingles witzh the nerve trunks, and ascending veins cover the plexus. Nerve fibers have a fairly vertical orientation, and go deep into the pelvis following the bony profile. Most caudal components are located posteriorly to the most cranial ones.

The radicular components from L4 and from L5, together, form the lumbosacral trunk. Receiving fascicles by S1, S2, and S3 roots, lumbosacral trunk contributes to the formation of common peroneal and tibial nerves, which may unite to form sciatic nerve or remain indipendent and parallel all the way to the popliteal fossa. From the sacral plexus also superior and inferior gluteal nerves, and motor branches to quadratus femoris, biceps and semitendineous muscles take origin.

Thus the subserved muscles are: major, middle and minor gluteal, obturator, piriform, gemelli and quadratus, the muscles of the posterior aspect of the thigh; anterior tibial and peroneal muscles, abductors and extensors of the foot; triceps surae and plantar flexors of the foot.

Patients and methods

Patients

This paper reports our surgical experience with 15 patients operated on from 1987 to 1996. Some of these patients were subject of previous reports [5, 6]. Mean age was 30; nine were males, six female.

In seven patients the lesion was due to road or work injuries; five out of these were males. In other 4 cases (all males) the lesion was due to bullets, while in 4 females the lesion was the consequence of abdominal or gyneacologic surgery.

Patient features are detailed on Table 1.

Diagnostic methods

All patients where referred because of the diagnosis of lumbosacral plexus lesion at distance from the lesional event. EMG recordings and Sensory Evoked Potentials were regularly repeated monthly in order to monitor the clinical evolution and get an understanding of the possibilities of spontaneous recovery.

EMGraphic signs of dysfunction in muscles innervated by different terminal branches were studied to make a map of the possible site of damage; SEP recordings from specific cutaneous areas were analyzed in order to identify possible root damage.

As indicated by Harris [19] and some other authors [9, 22, 28] myelography and TC myelography were performed in cases in which

Table 1. *The features of patient's lesion, and the surgical treatment which has been performed*

Pat.	Sex-age	Cause*	Level of lesion	Preoperative picture	Surgical approach	Surgical treatment
1-L.R.	M 20	1	L3-L4	Femoral M1 Obturator M3	extraperit.	neurolysis
2-N.R.	F 21	1	L5-S1-S2	Gluteal M2 Ant.Tib M3 Post. Tib M2	transperit	neurolysis
3-E.V.	M 32	2	L4	Femoral M2 Obturator M3	extraperit	graft
4-D.J.	M 28	2	sciatic trunk	Gluteal M0 Sciatic(thigh) M0 Ant.Tibial M0 Post.Tibial M0	sacrectomy + gluteal approach	graft
5-D.M.	F 42	3	lumbar pl. & term. branches	Femoral M3 Obturator M3	transperit	neurolysis
6-A.A.	F 40	3	lumbar pl. & term. branches	Femoral M2-3 Obturator M2	transperit	neurolysis
7-Y.D.	M 22	2	L4-Femoral n.	Femoral MO Obturator M2	extraperit	graft
8-M.E.	M 30	2	L5-S1	Gluteal M2 Ant.Tib. M0 Post.Tib M2	transperit	graft
9-A.C.	F 38	3	femoral + obturator + femorocutaneous	Femoral M3 Obturator M3	extraperit	neurolysis
10-R.S.	M 37	1	L5-S1-S2	Gluteal M1 Ant.Tib M2 Post.Tib M3	transperit	neurolysis
11-S.F.	F 27	3	femoral & obturator	Femoral M3 Obturator M3	transperit	neurolysis
12-A.B.	F 16	1	L3-L4-L5	Femoral M2 Obturator M2 Gluteal M4 Sciatic(thigh) M3	transperit	neurolysis
13-R.G.	M 18	1	L3-L4	Femoral M3 Obturator M3	extraperit	neurolysis
14-C.A.	M 63	1	L4-L5-S1-S2	Femoral M3 Sciatic(thigh) M1 Ant.Tib. M0 Post.Tib. M0	transperit	graft
15-G.G.	M 54	1	L3-L4-L5	Femoral M3 Obturator M3 Ant.Tib. M3	transperit	neurolysis

* Cause 1 is traumatic event in road or work accidents; cause 2 is bullet; cause 3 is gynecologic or abdominal surgey.

a suspicion of root avulsion was present because of the mechanism of injury: palsies associated with lumbar, sacral or pelvic fractures which my entail stretch injury to the nerves.

Patients were studied also by CT and/or MR imaging. These imaging tools provided information about alterations of anatomy [4, 16, 17], about the presence of bone displacements or fibrotisation in the retroperitoneal space, and about muscular atrophy.

Surgical methods

The approach to the lumbosacral plexus area may be a difficult matter because of the deep location of nervous structures, which in the retroperitoneal space are covered by major arteries, veins, and venous plexuses. Fibrotisation following retroperitoneal haematomas and traction – distortion lesions may become very compact because of frequent participation of bone repair processes and because of the involvement of thick muscles with very numerous tendinous insertions.

Owing to the level of lesion three different approaches are described in the literature: [7, 14, 18]:

- anterior extraperitoneal via a lumbotomy, for reaching L2-L3-L4 roots and lumbar plexus
- anterior transperitoneal via a xifopubical incision for reaching L5-S1-S2 roots and sacral plexus
- posterior via L5 laminectomy and sacrectomy for reaching the nerve toots and the deep intrapelvic origin of sciatic nerve from sacral plexus.

Combined anterior and posterior approach is described only from a theoretical point of view: no reports on patients treated by this double approach could be found in the literature.

Millesi recently realized a very new approach which goes along the inner bony surface of iliac bone and enlarges the margins of foramen ischiaticus in order to expose the sacral plexus and sciatic nerve at the passage through the foramen [27].

In this series of 15 patients, surgical approach was chosen following the aforecited criteria, and also considering the previously performed surgical operations for each individual patient, which in some cases imposed the transperitoneal approach.

After neurolysis, nerve grafting procedures were performed in 2 of the lesions due to trauma, in all four due to bullet injury, and in 1 of the four iatrogenic lesions.

Surgical procedures

The anterior extraperitoneal approach

The patient lies on lateral decubitus on the healthy side with the bed forming a 30 degree angle corresponding to the lumbar area. The arm on the affected side is kept elevated over the head.

A lumbotomic incision is performed: the arciform skin incision and section of oblique muscles gives exposure of the peritoneal sac, which is gently retracted medially and downwards. The kidney is visible on the cranial limit of the operative field, on the posterior abdominal wall. Attention must be payed to the ureter, which runs inside a duplication of the peritoneal wall and must not be hurted in dislocating the peritoneum. By this way the plane of psoas and ileum muscles are exposed; femorocutaneous, femural and genitofemoralis nerves are easily identified and the appropriate microsurgical procedures can be performed. Tracing posteriorly the femoral nerve, we usually elevate the psoas muscle by a strong retractor, in order to reach L2, L3, and L4 roots at the foramina. In this point electrical stimulation is given while evoked cortical potentials are recorded for demonstrating the absence of root avulsion. Distally the terminal branches of the lumbar plexus are followed up to their way out of the pelvis. If needed femoral nerve is neurolysed by dividing the ligamentum inguinalis on the lacuna musculorum, and coming into the Scarpa's triangle in the thigh.

The same can be done for the femorocutaneous nerve by dividing the ligamentum inguinalis laterally, close to the anterior superior spina iliaca, and opening the fascia lata.

The obturator nerve can be traced distally: it is medial to the psoas muscle, and lateral and posterior to the iliac vein, and goes towards the canalis obturatorius.

In this series this approach was applied in 5 cases. In 3 out of them the target was a lesion of L3 and/or L4 roots. This site of lesion was associated with femoral nerve involvement in patient n° 7, and with femoral, obturator and femorocutaneous nerves lesion in patient n° 9.

Microsurgical treatment consisted in neurolysis in 2 cases, which showed that grafting procedures were needed in patients

The anterior transperitoneal approach

The patient lies on its back, the bed forming a 20 degree angle corresponding to the lumbar area. A long xifopubic skin incision allows bringing apart the two recti abdominis muscles. The anterior wall of the peritoneal sac is opened and bowels are retracted. For maintaining a central free space we have employed a circular autostatic spreader which can retract bowels in any direction without danger.

The posterior peritoneal wall is opened and major vessels are exposed. Once the vessels are gently retracted, the promontorium, that is the body of L5 vertebra and L5-S1 disk, can be palpated. This is the landmark for identifying the L5 nerve root. Nerve roots L4 and L5 can be reached medial to the psoas muscle, and their fusion in the lumbosacral trunk is exposed by partial resection of the muscle from medial to lateral. S1 root can be brought into vision more distally. Surgical procedures on its junction to the sacral plexus become extremely difficult; we believe that only neurolysis is possible at this level. Up to some millimeters exposure becomes impossible because of the very deep location and the presence of not movable vascular structures. So this is the distal limit of the surgical field. This is why more distal lesions at the passage from the pelvis to ischiatic foramen are to be approached by the posterior route.

Out of our 15 patients this approach has been used in nine cases. In 3 the target was a lesion located in L5 root and in more distal roots. In other complex lesions in which L5 root was involved together with the upper roots composing the lumbar plexus, the choice was in favour of this approach rather than the extraperitoneal one (patients n° 12 and 14).

In four patients the choice for this surgical approach was dictated by preexisting abdominal scar, even if the goal was to reach the lumbar plexus and its terminal branches (patients n° 5, 6, 11 and 15).

The posterior approach

The patient lies prone, with the the legs maintained in hip and knee flexion as for lumbar disk surgery. This position allows sacrectomy and L5 emilaminectomy, careful muscular resection from sacral insertions and intrapelvic plexus exposure. Also sciatic nerve exposure distal to the foramen ischiaticus underneath gluteal muscles is easyly performed by a distal separate approach [7, 24].

After medial lumbar skin incision, L5 and S1 roots are exposed by laminectomy and sacrectomy followed by foraminotomy. The paravertebral muscles are to be partially sectioned in order to gain a lateral extension of the surgical field and exposure of the retroperitoneal space. Neurolysis can be performed by this approach and if needed nerve grafting can be performed with connection to the sciatic nerve at foramen ischiaticus. Nerve grafts are brought beneath the gluteal muscles, outside the pelvis.

This approach was employed in only one case, in which the sciatic trunk was lesioned in the pelvis, and had to be repaired by grafts (patient n° 4).

Results

We had no complications from surgery, all postoperative courses were uneventful.

Follow up in our series of patients was at seven years for 3 cases, three years for 2, two years for 4 and 18 to 12 months for 6. In Table 2 the legend "postoperative picture" refers to the situation as observed at present, after the mentioned follow-up period after surgery.

EMG recordings demonstrated that gluteal muscles regained significantly useful innervation in neurolysis cases as well as in graft cases. Particularly the medium gluteus muscle, which is an important stabilizer of articulation, regained useful activity within one year after surgery. Muscles of the thigh showed an analogous improvement.

In general, most proximal muscles improved much more than the more distal ones. Among these the muscles subserved by the anterior tibial nerve had the worst results.

Table 2. *The correlation of results with kind and site of injury, and with the preoperative condition*

Patient	Sex-age	Cause	Surgical treatment	Preoperative picture	Postopertive picture
1-L.R.	M 20	1	neurolysis	Femoral M1	M4
				Obturator M3	M5
2-N.R.	F 21	1	neurolysis	Gluteal M2	M4
				Ant.Tibial M3	M3
				Post.Tibial M2	M4
3-E.V.	M 32	2	neurolysis + graft	Femoral M2	M3
				Obturator M2	M3
4-D.J.	M 28	2	neurolysis + graft	Gluteal M0	M3
				Sciatc(thigh) M0	M3
				Ant.Tibial M0	M0
				Post.Tibial M0	M0
5-D.M.	F 42	3	neurolysis	Femoral M3	M5
				Obturator M3	M4
6-A.A.	F 40	3	neurolysis	Femoral M2–3	M4–5
				Obturator M3	M4
7-Y.D.	M 22	2	neurolysis + graft	Femoral M0	M3
				Obturator M2	M3
8-M.E.	M 40	2	neurolysis + graft	Gluteal M2	M4
				Ant.Tibial M2	M2
				Post.Tibial M0	M3
9-A.C.	F 38	3	neurolysis	Femoral M3	M4–5
				Obturator M3	M4
10-R.S.	M 37	1	neurolysis	Gluteal M1	M4
				Ant.Tibial M2	M4
				Post.Tibial M3	M5
11-S.F.	F 27	3	neurolysis	Femoral M3	M5
				Obturator M3	M5
12-A.B.	F 16	1	neurolysis	Femoral M2	M4
				Obturator M2	M4
				Gluteal M4	M5
				Sciatic(thigh) M4	M5
13-R.G.	M 18	1	neurolysis	Femoral M3	M4
				Obturator M3	M4
14-C.A.	M 63	1	neurolysis + graft	Femoral M3	M4
				Sciatic(thigh) M1	M3
				Ant.Tibial M0	M0
				Post.Tibial M0	M2
15-G.G.	M 54	1	neurolysis	Femoral M3	M5
				Obturator M2–3	M4
				Ant.Tibial M3	M3

The woman treated by grafting because of a surgical lesion of the obturator nerve had a very good recovery, probably because of the clearcut lesion, and of the correct timing for reconstruction.

Among the graft cases one did not show improvement 18 months postoperatively. We cannot exclude that a root avulsion was the cause of this failure, but since the repaired structure was the L5 component of the lumbosacral trunk we think that muscle distance may have played as primary role.

For all patients surgery meant improvement in pain sensation; in the great majority pain disappeared, and this result was achieved almost immediately in the postoperative period. This is ascribed to neurolysis which allows resolution of ischemia.

Conclusions

Patients suffering a lumbosacral plexus lesion may have a very severe problem whith deambulation since the leg may not be able to withstand the body wheight. Also in cases of partial lesion impairment of various muscles from the gluteus to the foot will engender problems with motion. Moreover, the pain syndrome following nerve lesions will be exacerbated by posture and will hinder walking and rehabilitation programs.

As for any peripheral nerve lesion, the entity of damage may vary greatly from trunk to trunk and even inside a single nerve structure. Neurolysis, either as a first step procedure for studying the lesion or as a per se complete treatment, is a useful technique to facilitate nerve regeneration and appease neurogenic pain.

The problem in lesions of lumbar and sacral plexuses is the relevant distance to the depending muscles. Only some muscle groups are near enough to be reached by nerve regeneration in a time short enough to prevent postatrophic fibrotisation. The muscles with the best results are the gluteal muscles, with the medium gluteus in particular. This muscle is very important for standing and walking since it gives stability to the hip joint.

Concerning the lumbar plexus, psoas and ileopsoas muscles are the most proximal: the psoas muscle will be reinnervated by branches of the lumbar plexus joining it directly at L2 and L3, while the ileopsoas muscle will receive regrowing fascicles through the femoral nerve.

As regards the sacral plexus, gluteal muscles and muscles of the posterior aspect of the thigh can be reinnervated via the gluteal nerves and via the specific short branches of the sciatic nerve.

Function improvement of these muscular masses deriving from neurolysis or from nerve grafting in more severe nerve lesions offers to the patient the enormous advantage of regaining strength for the leg. To be able to stand on it whithout external support will be the basis for starting walking again. Great enthusiasm of the patient who also enjoys reduction of pain will facilitate the rehabilitation program.

All the other more distal muscles of the inferior limb are too far distant and we should not expect useful reinnervation of this area when planning nerve grafting for lumbosacral plexus lesions. Anyway, posterior tibial depending muscles have shown significant degrees of reinnervation.

Neurolysis has proved to be a useful procedure in the retroperitoneal area since it could be achieved to gain 1 or 2 M points, making deambulation possible without external support and since it has almost completely eliminated pain in all cases.

References

1. Adams JC (1964) Vulnerability of the sciatic nerve in closed ischiofemoral arthrodesis by nail and graft. J Bone Joint Surg Br 46: 748–753
2. Aldea PA, Shaw WA (1986) Lower extremity nerve injuries. Clin Plast Surg 14: 691–699
3. Alexandre A, Carteri A (1988) Il trattamento chirurgico delle lesioni traumatiche del plesso lombare. In: Atti del XXXVII Congresso della Società Italiana di Neurochirurgia, pp 151–154
4. Alexandre A, Spigariol F, Cisotto P, Di Toma F, Carteri A (1988) Aspetti radiologici nella diagnostica della patologia del Sistema Nervoso Periferico. In: Atti del XXXVII Congresso della Società Italiana di Neurochirurgia, pp 79–83
5. Alexandre A (1990) Lumbosacral Plexus injuries. Diagnosis and surgical treatment. XXXIII Congreso de la Sociedad Argentina de Neurocirugia, Mar del Plata
6. Alexandre A, Carteri A, D'ambrosio G, Di Falco G, Cisotto P, Zanata R (1990) Lesioni traumatiche del plesso lombosacrale. Trattamento microchirurgico. Il Sistema Nervoso Periferico 1: 52–54
7. Aramburo F (1986) Exposure of the Lumbo-sacral Plexus. Peripheral Nerve Repair Regeneration 4: 13–15
8. Bardeen CR, Elting AW (1901) A statistical study of the variations of the formation and position of the lumbosacral plexus in man. Anat Anz 19:124 u. 204
9. Barnett HG, Connolly EJ (1975) Lumbosacral nerve root avulsion. J Trauma 15: 532–535
10. Byrnes O, Russo GL, Ducker TB, Cowley RA (1977) Sacrum fractures and neurological damage. J Neurosurg 47: 459–462
11. Brunelli G, Vigasio A (1986) Lumbar and sacral plexus surgery. Peripheral Nerve Repair Regeneration 4: 21–25
12. Carruthers FW, Logue RM (1953) Treatment of fractures of the pelvis and their complications. Am Acad Orthop Surg Lect 10: 50
13. Clark JMP, Danos E (1965) Obstetrical palsy. J Bone Jt Surg B 47: 805–806
14. Farny J, Drolet P, Girard R (1994) Anatomy of the posterior approach to the lumbar plexus plock. Can J Anaesth 41: 480–485
15. Froman C, Stein A (1967) Complicated crushing injuries of the pelvis. J Bone Jt Surg B49: 24–32
16. Gierada DS, Erickson SJ, Haughton VM, Estkowski LD, Nowicki BH (1993) MR imaging of the sacral plexus: normal findings. AJR Am J Roentgenol 160: 1059–1065
17. Gierada DS, Erickson SJ (1993) MR imaging of the sacral plexus: abnormal findings AJR Am J Roentgenol 160: 1067–1071
18. Guiot G, Martinez – Vanderhorst N (1964) Volet sacré. La Presse Medicale 56: 1317–1318
19. Harris WR (1974) Avulsion of lumbar roots complicating fracture of the pelvis. J Bone Joint Surg 55A: 1436–1442
20. Hope EE, Bodensteiner JB, Thomy N (1985) Neonatal lumbar plexus injuries. Arch Neurol 42: 94–95
21. Huttinen V (1972) Lumbosacral nerve injury in fracture f the pelvis. A postmortem radiogaphic and pathoanatomical study. Acta Chir Scand [Suppl] 429
22. Kline DG, Hudson AR (1995) Nerve injuries: oprative results for major nerve injuries, entrapments and tumors. W.B. Saunders Co, Philadelphia
23. Liguori R, Krarup C, Trojaborg W (1992) Determination of the segmental sensory and motor innervation of the lumbosacral spinal nerves. An electrophysiological study. Brain 115: 915–934
24. Linarte R, Gilbert A (1986) Trans-sacral approach to the Sacral Plexus. Peripheral Nerve Repair Regeneration 4: 17–20
25. Millesi H (1987) Lower extremity nerve lesions. In Terzis J (Ed): Microreconstruction of nerve injuries. Saunders Co., Philadelphia, pp 239–251

26. Millesi H (1992) Chirurgie der peripheren nerven. Urban & Schwarzenbzerg, Munich Wien Baltimore
27. Millesi H (1995) Palliative procedures for the lower limb. IV European workshop on microneurosurgery of peripheral nervous system. Bergamo 4–6
28. Moosey JJ, Nashold BJ, Osborne D (1987) Conus medullaris nerve root avulsions. J Neurosurg 66: 835–841
29. Mumenthaler M, Schliack H (1965) Lasionen peripherer nerven, diagnostic und therapie. G Thieme Verlag, Stuttgart
30. Patterson FP, Morton KS (1961) Neurologic complications of fractures and dislocations of the pelvis. Surg Ginec Obstet 112: 702–704
31. Pohlemann T, Gansslen A, Tscherne H (1992) The problem of the sacrum fracture, clinical analysis of 377 cases. Orthopade 21: 400–412
32. Vanni E, Nuti F (1963) Le fratture del sacro. Minerva Ortop 14–16
33. Webber RH (1961) Some variations in the lumbar plexus of nerves in man. Acta Anat 44: 336

Correspondence: Alberto Alexandre M.D., EU.N.I. European Neurosurgical Institute, Via Ghirada 2, 31100 Treviso, Italy. e-mail: alexandre@eunionline.com