Clinical Article
Results of the section of the filum terminale in 20 patients with syringomyelia, scoliosis and Chiari malformation

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Summary

Background. Spinal cord traction caused by a tight filum terminale may be considered a pathogenic mechanism involved in the development of syringomyelia, the Chiari malformation (type I) and scoliosis. Section of the filum terminale is proposed as a useful surgical approach in these conditions.

Methods. Between April 1993 and July 2003, a total of 20 patients (8 men and 12 women) with a mean age of 33.5 years underwent section of the filum terminale with or without opening of the dural sac through a standard sacrectomy. Eight patients suffered from scoliosis, 5 from syringomyelia, 2 from Chiari malformation and 5 with a combination of these conditions.

Finding. After section of the filum terminale, patients with syringomyelia showed an early clinical improvement of dysaesthesia, thermoanaesthesia, hypo-aesthesia and walking difficulties. Rising of the medullary conus was also observed. In patients with scoliosis, back pain improved dramatically and a curve reduction was noticed, although progression of the curve was observed in one case. In patients with Chiari malformation, headache, dysaesthesia and paraparesis disappeared.

Conclusions. Section of the filum terminale is a useful strategy in the treatment of scoliosis, syringomyelia and the Chiari malformation, and offers a new aetiological basis for the understanding of these three disorders.

Keywords: Syringomyelia; idiopathic scoliosis; Arnorld-Chiari malformation; tight filum terminale; filum section.

Introduction

Cord-traction symptoms caused by a tight filum terminale was initially suggested by Garceau [7] who reported three patients with paraparesis, scoliosis, headache and dysaesthesia who recovered following sectioning of a tight and thick filum. Jones and Love [14] used the term 'tight filum terminale syndrome' and reported six patients with spina bifida occulta the symptoms of which were attributed to an anchored conus medullaris. In all cases, symptomatic improvement was obtained after intradural lumbosacral exploration and resection of the filum terminale. Hamilton [10] and Roth [25, 26] established the hypothesis that stretching of the spinal cord was involved in the aetiopathogenesis of scoliosis and the Chiari malformation. Mau and Nebinger [17] reported that scoliosis may precede neurological symptoms of syringomyelia, and Ng and Seow [19] described a case of tethered cord syndrome preceding the development of a syrinx, which subsequently resolved with detethering. Based on medullary traction to be transmitted by the filum terminale as a possible common aetiopathogenic mechanism in syringomyelia, idiopathic scoliosis and the Chiari malformation, section of the filum terminale was proposed by our group as a useful treatment for these conditions [27–29], and this was successfully accomplished in five cases [30].

We here report the results of all "operated" cases of syringomyelia, scoliosis and Chiari malformation (type I) undergoing section of the filum terminale. The aim of the present series, however, was not to prove conclusively whether a tight filum terminale is the common aetiological agent of Chiari malformation, scoliosis and syringomyelia.

Patients and methods

From April 1993 to July 2003, a total of 20 non-consecutive patients (8 men and 12 women), aged between 12 and 70 years (mean 33.5 years), with scoliosis (n = 8), syringomyelia (n = 5), Chiari malformation (n = 2), and a combination of the three conditions (scoliosis, syringomyelia, Chiari malformation) (n = 5) underwent section of the filum terminale through a standard sacrectomy. All patients were symptomatic. None of the patients showed features of occult dysraphism. In 11 patients operated on up to 1999, the filum was sectioned (1 cm) with opening of the dural sac, whereas in the remaining 9 patients, who were operated on later, section of the filum terminale (1 cm) was carried out without opening of the dural sac.

Clinical and preoperative data of these patients (Table 1) are here summarised. Cases 1 to 5 have been previously reported [30].

Case 1

A 34-year-old woman presented with bilateral cervicobrachialgia associated with dysaesthesia and paraesthesia, and walking difficulties of about 3 year's duration. The neurological examination showed bilateral Babinski's signs. The magnetic resonance imaging (MRI) revealed a syrinx cavity from C3 to C7, and the lumbar MRI showed the conus medullaris at L1-vertebral level.

Case 2

A 26-year-old man was admitted with complaints of severe cervicobrachialgia and dysaesthesia in the left shoulder and the axilla, as well as dysaesthesia and thermo-anaesthesia in the left hemithorax. Symptoms had been present for about 2 years. Neurologically, deep tendon reflexes in the legs were increased. MRI showed a longitudinal syringomyelia cavity from the bulb to C6. The conus medullaris was found at the D12-vertebral level (Fig. 1).

Case 3

A 19-year-old woman with scoliosis from the age of 14, had a 4-year history of progressively frequent back pain episodes, increase in the curvature and dorsolumbar muscle contraction. On standing preoperative postero-anterior radiographs, a Cobb angle of 35° was measured. The neurological examination was unrevealing. MRI showed a prolapse of the cerebellar tonsils, tight spinal cord, and the medullary conus at the L1 level.

Case 4

A 67-year-old woman presented with frequent pain episodes in the cervical region, headache, weakness in the upper extremities and loss of temperature appreciation in both hands. Spasticity of the legs was referred by the patient as 'walking on cotton'. On neurological examination, there was hypo-aesthesia in both hands and hyperreflexia in the lower extremities. MRI showed tonsillar position at C1 and the medullary conus at L1 level.

Case 5

A 33-year-old man had been diagnosed with syringomyelia since the age of 10. Three years before consultation he underwent a posterior fossa craniectomy for the treatment of syringomyelia followed by vertebral fixation (D4–L3) one month later. A ventriculo-peritoneal shunt due to hydrocephalus was performed one year before consultation. On physical examination, there was significant tetraparesis (the patient could not walk and stand up by his own), amyotonia especially in the hands, hypo-aesthesia in the left leg, megacephalus, short neck, generalised hyperreflexia and bilateral Babinski's signs. MRI showed syringomyelia (C3–C7) in the fistulised and flaccid stage, Chiari malformation, scoliosis, hydrocephalus and the medullary conus at the L1 level.

Case 6

A 24-year-old man presented with a 3-year history of episodes of dorsolumbar pain that increased in severity and caused important disability. MRI showed a fusiform cavity (D7–D9), prolapse of the cerebellar tonsils, tight spinal cord particularly at the dorsal level. The medullary conus was found at the L1 level.

Case 7

A 27-year-old man complained of episodes of dorsal and lumbar pain with referred pain to the lower extremities of 6 years' duration. On examination, there was a positive Néri's sign and moderate dorsolumbar scoliosis (19.5° on the radiographs). MRI showed prolapse of the cerebellar tonsils, tight spinal cord and the conus medullaris at the L1–L2 level.

Case 8

A 12-year-old girl had a dorsolumbar scoliosis and was wearing a Milwaukee type brace. On radiographs 40° left dorsal and 40° right lumbar curves were noted. MRI showed the cerebellar tonsils below the foramen magnum, a tight spinal cord, the conus medullaris at the L1 level and the bottom of the dural sac immediately below L5.

Case 9

A 16-year-old girl presented with low back pain radiating to the legs and pain in the cervical region. A lumbar scoliosis (14° Cobb angle) was diagnosed. MRI showed disk protrusion at L5–S1 and the conus at L1 level.

Case 10

A 13-year-old girl presented with back pain due to dorsal scoliosis (25° Cobb angle). MRI was unrevealing except for a tight spinal cord.

Case 11

A 43-year-old woman had severe episodes of cephalea in the standing position which disappeared on lying down over the past year and was diagnosed with Chiari malformation elsewhere. MRI showed prolapse of the cerebellar tonsils below the lower edge of the atlas. A tight and thick filum terminale was observed on conventional myelography and myelo-computed tomography (CT) scan (Fig. 2). A cerebrospinal fluid leak was detected at the sacral level (Fig. 2).

Case 12

A 18-year-old woman had a long-standing history of back pain with referred pain and muscle contracture in the left dorsolumbar region. Neurologically, weakness of the left hand and left Babinski's sign was found. On the radiographs, the lumbar curve measured 48°. In the MRI, the cerebellar tonsils were below the foramen magnum and the caudal end of the dural sac was found at L5-S1 level.

Table 1. *Surgical data and outcome in patients with syringomyelia, idiopathic scoliosis and Chiari malformation (type I) undergoing section of the filum terminale (SFT)*

Case	Sex, age	Diagnosis	Operation and date	Postoperative findings	Observations	Outcome (September–October, 2004)*
1	F, 34 years	Syringomyelia	SFT, October 10, 1993	disappearance of symptoms	MRI decrease in height and increase in width of the cavity	unknown
2	M, 26 years	Syringomyelia	SFT, February 2, 1994	disappearance of symptoms in 6 hr	MRI decrease in syrinx height and increase in width, rising medullary conus D12	90% clinical improvement, yes, very useful
3	M, 19 years	Scoliosis	SFT, June 16, 1994	disappearance of symptoms	Improvement of 6° in 20 months	unknown
4	F, 67 years	Chiari	SFT, June 3, 1994	significant improvement, restoration of thermal sensitivity in the hands	prolapsed cerebellar tonsils	50% clinical improvement, yes, useful
5	M, 33 years	Syringomyelia, scoliosis, Chiari	Craniectomy, vertebral fixation, V-P valve prior to SFT, July 15, 1996	significant clinical improvement	reflexes recovered, go up stairs by his own	unknown
6	M, 24 years	Syringomyelia	SFT, December 29, 1997	disappearance of symptoms	back to work as a mason 3 months later	95% clinical improvement, yes, very useful
7	M, 27 years	Scoliosis	SFT, April 1, 1998	disappearance of cervical and lumbar pain, improvement of dorsal pain	mild dorsal pail persisted	20% clinical improvement, no, not useful
8	F, 12 years	Scoliosis	SFT, July 6, 1998	improvement of back pain	4° increase of scoliosis	consultation elsewhere
9	F, 16 years	Scoliosis	SFT, September 21, 1998	improvement 8°	asymptomatic	90% clinical improvement, yes, very useful
10	F, 13 years	Scoliosis	SFT, October 10, 1998	improvement 6°	asymptomatic	10% clinical improvement, yes, very useful
11	F, 43 years	Chiari	Suture sacral dural fistulas, SFT, June 10, 1999	disappearance of symptoms	sacral fistulas	100% clinical improvement, yes, very useful
12	F, 18 years	Scoliosis	SFT, October 16, 2000	disappearance of symptoms	asymptomatic., filum terminale retraction	60% clinical improvement, yes, useful
13	M, 70 years	Syringomyelia Scoliosis	SFT, June 6, 2001	disappearance of symptoms	disappearance of symptoms	exitus due to laryngeal carcinoma
14	F, 46 years	Scoliosis	SFT, September 11, 2001	disappearance of back pain and paraesthesia	asymptomatic after operation	80% clinical improvement, yes, very useful
15	F, 50 years	Syringomyelia	Right L4–L5 hemilaminectomy, SFT, September 27, 2001	improvement of paraparesis disappearance of back pain	waking without support	40% clinical improvement, yes, useful
16	M, 20 years	Syringomyelia, scoliosis, Chiari	SFT, December 10, 2001	disappearance of dysaesthesia	asymptomatic	40% clinical improvement, yes, useful
17	M, 53 years	Syringomyelia Scoliosis	SFT, February 2, 2002	disappearance of cramps	paraparesis and vital capacity improved	30% clinical improvement, yes, useful
18	F, 33 years	Scoliosis	SFT, December 12, 2002	disappearance of cervical pain	asymptomatic, 3 cm filum retraction	30% clinical improvement, yes, useful
19	F, 39 years	Syringomyelia Scoliosis	SFT, March 25, 2003	disappearance of pain, pharyngeal oppression and Babinski's sign	asymptomatic, 1 cm filum retraction improvement	40% clinical improvement, yes, useful
20	F, 37 years	Syringomyelia	SFT, September 15, 2003	disappearance of occipitocervical pain and hypoaesthesia	asymptomatic, 3 cm filum retraction	100% clinical improvement, yes, very useful

* Percentage of clinical improvement (0% to 100%), would you agree to be operated on again according to the results obtained? (yes/no), do you consider that operation was very useful, useful, not useful, harmful?
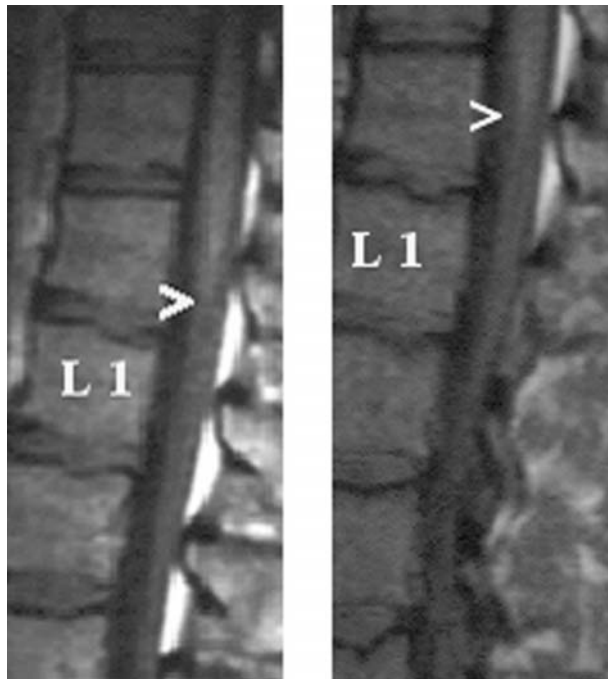
Fig. 1. Case 2. The preoperative lumbar MRI shows the conus medullaris at the inferior edge of D12 (left). In the postoperative MRI, the conus is seen at the middle of D12 vertebral body

Case 13

A 70-year-old man had been diagnosed with syringomyelia since the age of 17 and complained of hypo-aesthesia of the right thigh, amyotrophy of the right hand, frequent cephalea and back pain. The CT scanning showed tetraventricular hydrocephalus, the plain radiographs

disclosed a lumbar scoliosis and the MRI a flaccid cavity at C3–C7, a tight filum terminale and the bottom of the dural sac at L5-S1 level.

Case 14

A 46-year-old woman presented with scoliosis since childhood and complained of back pain with paraesthesia and dysaesthesia in the lower extremities. MRI showed the caudal end of the dural sac at the L5-S1 level.

Case 15

A 50-year-old woman had sciatic pain in the right leg and walking instability. The neurological examination showed Lasègue's sign, paretospastic walking and bilateral Babinski signs. MRI showed a central cavity (hydromyelia) and C4–C5 disk protrusion, with the medullary conus at L1 and the dural sac at the S1 level.

Case 16

A 20-year-old man complained of 1-year history of right cervicobrachialgia and dysaesthesia in the right half of the body. Moderate lumbar scoliosis was seen on the plain radiographs. MRI revealed syringohydromyelia C1-D10, prolapsed cerebellar tonsills and the conus medullaris at the L2 level.

Case 17

A 53-year-old man presented with severe cervicodorsolumbar scoliosis (90°) and severe impairment of the lung vital capacity (24%) that required ambulatory oxygen and treatment with continuous positive airway pressure at night. He had weakness of the left leg. Hyperreflexia in both lower extremities and a left extensor plantar reflex were found on physical examination. MRI showed a flaccid cavity from C3 to D7 and a very severe scoliosis.
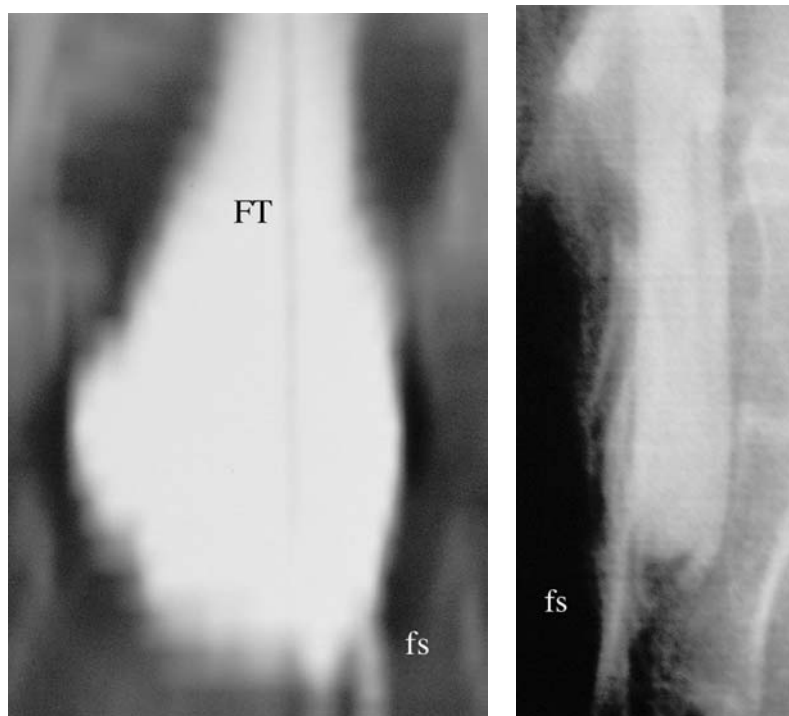

Fig. 2. Case 11. Myelo-CT scan shows the filum terminale (*FT*) at the lumbosacral level with enlargement of the cauda equina and leak of contrast through a sacral fissure (*sf*). Anteroposterior view (left) and lateral view (right)
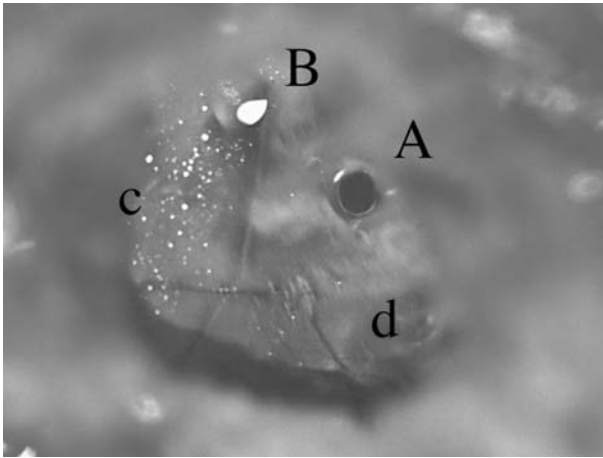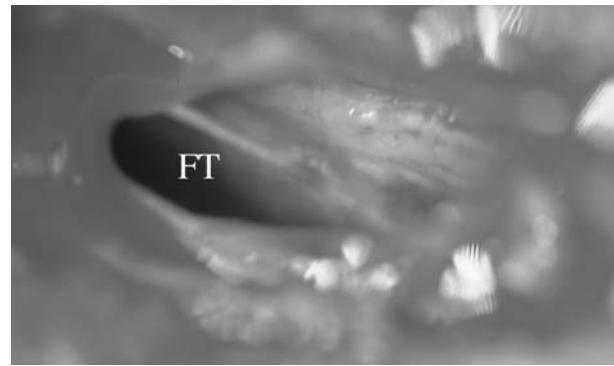
Fig. 3. Case 11. Sacriectomy showing two holes (A and B) in the dura mater (d) caused by friction of a tight and thick filum terminale (left). Visible filum when the sacral fistula is enlarged (right)

Case 18

A 33-year-old woman presented with dorsal scoliosis, hypo-aesthesia in the internal surface of the left upper limb and left hemithorax with paraesthesia of the left hand. MRI revealed a significantly rotated scoliosis, cerebellar tonsils 1 cm below the foramen magnum, and a tight spinal cord.

Case 19

A 39-year-old woman had a history of 45° scoliosis, D9-L5 arthrodesis and C1–C2 laminectomy for the treatment of cervical syringomyelia. She was visited because of back pain, severe pain in the occipital and cervical regions with pharyngeal compression and waking instability. On neurological examination, there was left hemiparesis, absence of the biceps and triceps reflexes on both sides and bilateral Babinski signs. MRI showed syringomyelia (flaccid cavity from C3 to C7) and the medullary conus at the L1 level.

Case 20

A 37-year-old woman had occipitocervical pain, lumbar pain, hypo-aesthesia in both arms and the right lower limb. The CT scan showed disc protrusion at C4–C5 and C5–C6, and the MRI disclosed hydromyelia from C5 to the medullary cone.
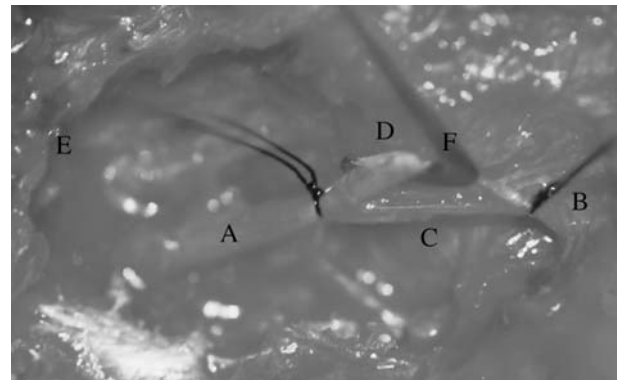
Results

At operation, lack of elasticity of the filum was observed in all patients being inelastic in 50% of cases. The diameter of the filum terminale ranged between 0.5 mm to 4 mm (mean 1.72). Details of operation of Cases 2 and 11 are shown in Figs. 3 and 4, respectively. After section of the filum, the spinal cord ascended and relaxed, resulting in 1- to 3-cm gap between the two-sectioned ends. Histopathological examination of the filum fragments showed fibrosis and unspecific nervous tissue similar to that of the spinal cord.

Fig. 4. Case 14. Operative field after standard sacriectomy. The filum terminale is extracted from the dural sac which is secured by two silk sutures. (A) Proximal filum terminale with the dural sac. (B) Distal filum terminale and its insertion in the sacrum. (C) Dural sheath of the filum. (D) Filum without dural sheath. (E) Proximal portion, sacriectomy. (F) Curved forceps removing the filum terminale from its dural sheath

In all patients, clinical symptoms and signs disappeared or improved substantially immediately after operation especially in terms of pain relief. In Case 8, a dural fistula occurred which closed spontaneously. Patients undergoing section of the filum terminale without opening of the dural sac were discharged from the hospital after 24 hours. The mean length of stay in patients in whom section of the filum was performed after opening the dural sac was 4 (± 2) days. Patients with scoliosis had radiographic assessments at 6 months after operation and annually thereafter. The follow-up ranged from 4 months to 11 years.

In patients with syringomyelia, the syrinx showed a few changes after section of the filum. In two cases, there was a decrease in the longitudinal diameter of

the cavity and an increase in the transversal diameter. MRI showed that the conus medullaris ascended in two cases (Cases 2 and 16). Improvement of the scoliotic curves was observed in all patients with scoliosis except in Case 8. Results of operation and outcome are detailed in Table 1.

Discussion

The concept of the tethered cord syndrome developed slowly but with increasing interest amongst clinicians and neurosurgeons. The unusual association of the Chiari malformation with myeloschisis was suggested as early as 1940 [39]. In patients with myeloschisis, there is an abnormal traction causing the cord and the cerebellum to shift through the foramen magnum. The mechanical traction hypothesis has been supported by a number of authors [15, 21, 33], and according to Fitz [5] the tethered conus, also called tight filum terminale syndrome, is the simplest anomaly of posterior lumbar dysraphism. However, the tethered cord syndrome may also occur in patients who have the conus in the normal position [18, 31, 32, 37]. It has been shown that the tight filum terminale may cause spinal cord compression over an angulated spine as well as cord traction, pulling the hind brain into the foramen magnum. The role of the filum terminale as a cause of scoliosis has also been suggested [7]. A dynamic interpretation of the Chiari malformation as a result of a cranio-cervical growth conflict was proposed by Roth [25, 26]. Studies in experimental models carried out by Yamada [38, 39], indicate marked metabolic susceptibility to hypoxic stress to lumbosacral cord under traction. Similar effects were demonstrated in redox behaviour of human tethered cord during surgical procedures. It is concluded that symptoms and signs of tethered cord are concomitant with lumbosacral neuronal dysfunction, which could be due to impairment of mitochondrial oxidative
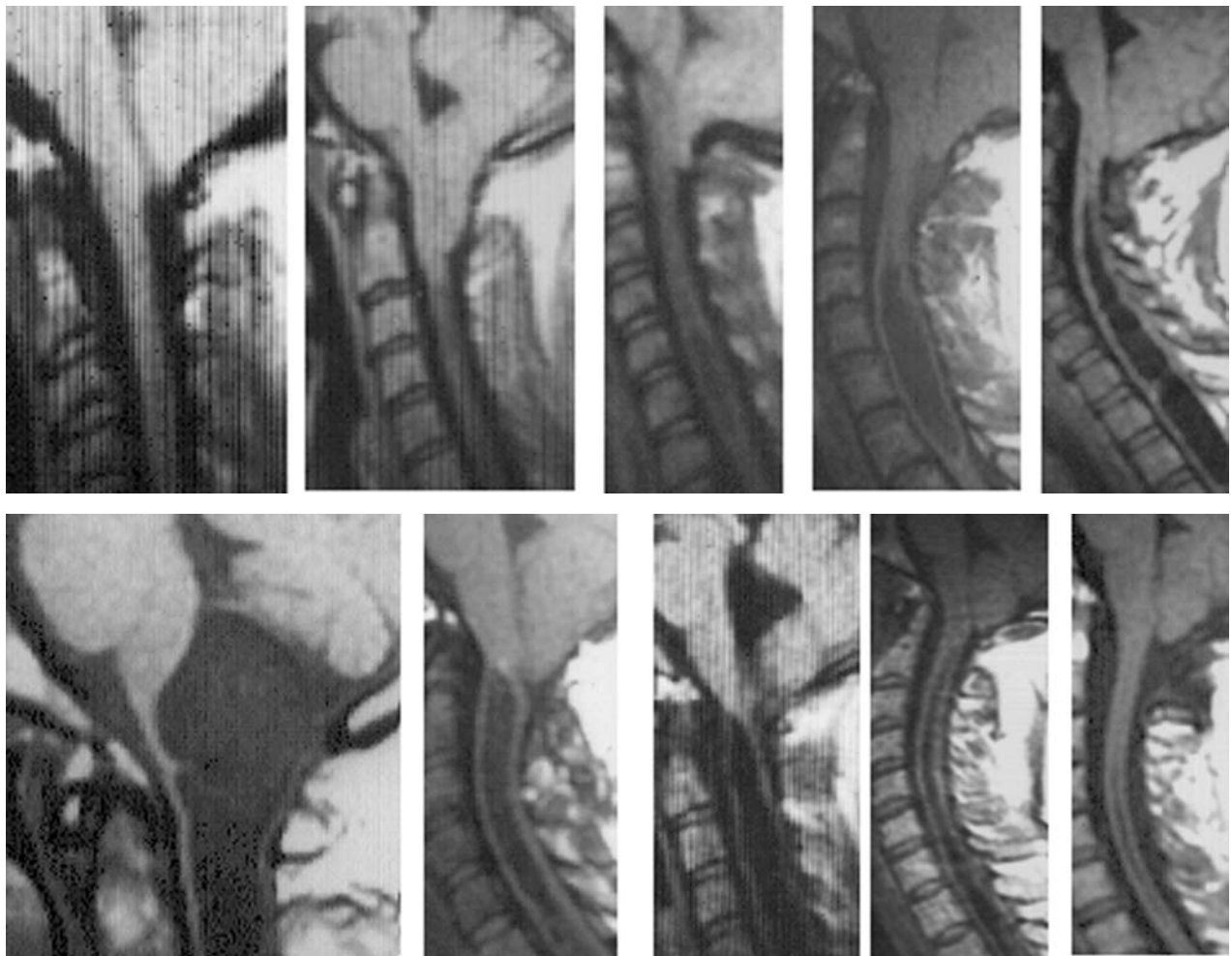

Fig. 5. Phases of the formation of the syringomyelia cavity. Chronological pathogenesis based on cervical MRI findings [28]

metabolism under constant or intermittent cord stretching. Untethering procedures in human tethered cord improve oxidative metabolism, and probably facilitate the repair mechanism of injured neurons.

According to abnormal traction of the spinal cord, the Chiari malformation, scoliosis and syringomyelia could be all an expression of the same process [27–30] as an attempt to prevent increasing tethering (scoliosis), evidence of traction on the lower part of the cerebellum (Chiari) and centrospinal ischemia resulting in a cystic cavity (syringomyelia). The different aspects of a syrinx cavity are illustrated in Fig. 5.

Posterior fossa decompressin with removal of the rim of the foramen magnum is considered the surgical treatment that offers the better results in cases of syringomyelia and Chiari malformation, improving circulatory pathways of the cerebrospinal fluid and eliminating the obstacle in the shifting of the content of the posterior fossa and the support to the tethering cord strength. Expansion of a syrinx following posterior-fossa decompression of an associated Chiari type I malformation has been reported [9]. On the other hand, steady excessive tension in the spinal cord and accentuated by repeated stretching related to flexion or extension movements cause impairment of the oxidative metabolism, neuronal dysfunction and eventually irreversible neurological deficits [4, 8, 24, 36].

Release of cord tethering, thereby allowing the spinal cord to resume normal tension is the basis of the surgical treatment in patients with tethered spinal cord symptomatology. Yamada [38, 39] has pointed out that if untethering is performed before there is irreversible neurological damage, improvement in motor and sensory function is achieved. The immediate improvement of symptoms in some patients with syringomyelia after sectioning of the filum terminale may be attributed to relief of traction and compression of the pericavitary medullary tissue, improving centrospinal ischemia and the tumour-like effect of the tractioned syringomyelia cavity. Improvement of angulation in scoliosis may be related to disappearance of flexion stimulus aimed at compensating spinal cord traction. Improvement of symptoms and signs in the Chiari malformation may be associated with disappearance of strength causing caudal displacement of the cerebral tonsils as well as relief of the tension over the cervical cord caused by the impacted tonsils.

In 1992, Mathern and Peacock [16] described the importance of the tethering mechanism in the pathophysiology of scoliosis associated with diastematomyelia and suggested that it is often possible to correct the scoliosis deformity by dealing only with the diastematomyelia by untethering the cord. In the same year, Park and Kaufman [20] proposed a myelotomy of the conus to treat a syrinx associated with spinal dysraphism; the operation in such cases is referred to as terminal ventriculostomy as introduced by Gardner. In 12 patients who underwent terminal ventriculostomy for syringomyelia, Gardner et al. [6] reported that opening the central canal at the tip of the conus improved the symptoms of syringomyelia and syringobulbia, although this effect is more likely to be related to release of excessive tension after sectioning of the filum terminale [20, 27, 39].

Sutton et al. [34] reported traction of the spinal cord as a mechanism involved in the pathogenesis of lipomyelomeningocele and proposed untethering the spinal cord by section of the filum terminale. Reigel et al. [24] described decline in the spinal curvature following release of tethered spinal cord associated with spina bifida. Other authors have shown beneficial results after surgical treatment of a tethered spinal cord in spinal dysraphism [1, 12, 13, 22]. Untethering procedures have been associated with cranial displacement of the conus medullaris intra-operatively [1] or in the follow-up radio-imaging studies [19]. In all the cases here reported, the cut ends of the filum separated significantly and instantaneously after sectioning. Moreover, in two cases of syringomyelia, after section of the filum there was a decrease in the longitudinal diameter and an increase in the transverse diameter of the cavity, which further support a traction axial pull. In one patient with the Chiari malformation (Case 11), there was a spontaneous sacral cerebrospinal fluid fistula at the friction zone of a thick and tight filum but no reference to this condition has been found in the literature. Although the tethered cord-related ischemic mechanism involved in the pathogenesis of the syringomyelia cavity is eliminated by sectioning of the filum, disappearance of the syrinx should not be expected, which in turn will take place after fistulisation and eventual collapse [27–29]. In addition, after sectioning of the filum terminale, upper displacement of the conus and the cranial segment of the filum may occur.

In summary, section of the filum terminale has been performed successfully by others for the treatment of scoliosis and lumbar medullary syndromes [2, 3, 14, 18, 19, 23, 31–35, 38, 39]. The tethered cord syndrome has been proposed as a mechanism involved in the pathogenesis of the three disorders, –scoliosis, syringomyelia, Chiari malformation–, and the beneficial effects

of section of the filum in scoliosis and neurological manifestations of syringomyelia have been reported [2, 9, 23, 24, 27–30], although in some cases it was not interpreted in relation to the effects of a tight filum [6]. Based on the present results and the clinical manifestations of the patients here reported together with the pre and postoperative findings it is concluded that section of the filum terminale is a useful strategy in the treatment of scoliosis, syringomyelia and the Chiari malformation, and offers a new aetiological basis for the understanding of these three disorders. However, experiments that opposed this proposal, e.g., animal experiments which failed to produce Chiari I malformation or spinal tethering by pulling down the filum or the occurrence of Chiari malformation in animals that do not use the standing position are necessary.

Acknowledgement

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Comments

The value of the paper is to stimulate the attention of neurosurgeon towards the possisble role of a tight filum terminale in the genesis of a variety of disturbances of spinal cord function. The authors report on the clinical improvement of a series of patients with idiopathic scoliosis, syringomyelia, Chiari malformations, and a combination of such conditions who improved following the intradural or extradural section of the filum terminale. The authors' experience is corroborated by several reports the authors found in the literature pointing to the role of a tight filum in determining a tethered cord sysndrome. The theory of a tight filum pulling down the spinal cord and the cerebellar tonsils, leading to a Chiari type I malformation, is quite old and widely accepted though never demonstrated in experimental animals. Indeed, such a mechanical theory has the advantage to be easy to understand. Furthermore, it is a common experience that symptomatic patients with a low-lying conus associated with a thick filum terminale may benefit from surgical treatment. The physiopathogenetic interpretation becomes more difficult when the concept of a tight filum leading to spinal cord impairment is applied to subjects whose conus medullaris is in a normal position, as in many of the patients here considered. In fact, even though one could propound a pathological limitation of the spinal cord physiological movements in case of an excessively tight filum (which theoretically could benefit by a surgical release) it is not clear to me why after the section of the tight filum the "normally" placed conus should ascend into the spinal canal. Actually, the authors state that in all their cases the "ends of the filum separated significantly and instantaneously after sectioning".

Obviously, the good surgical results obtained by the authors deserve careful analysis, as they imply that a number of subjects, with pathological conditions, similar to those described in the present paper could not enjoy a therapeutic advantage just because they are not correctly diagnosed. Unfortunately, the surgical indication is not easy in patients whose conus medullaris is in a normal position and the authors do not describe criteria on which the surgical option should be based, when considering the heterogeneous clinical manifestations and the multiple pathological findings on the MRI.

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The manuscript proposes a rationale which is of interest, since there is still debate on the aetiology of the presented clinical complex.

The title raises the question whether a tight filum terminale is the common aetiological agent of CHIARI-malformation type I, scoliosis and syringomyelia. The paper finally does not conclusively prove this theory. The authors present 20 patients without evidence of occult dysraphism but one ore more of the respective clinical signs and offer to them a relatively easy procedure for definite treatment of the complex clinical entity by simply cutting the filum. In 9 patients no dural opening was performed. This would be revolutionary in the treatment concepts for these diagnoses. But many questions are left open.

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