Surgical treatment in a patient with Klippel–Feil syndrome and anterior cervical meningocele: a case report and review of literature

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Received: 17 January 2013 / Accepted: 1 April 2013 / Published online: 12 April 2013
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Abstract

Introduction Klippel–Feil syndrome (KFS) is considered a rare developmental disorder characterized by mono- or multisegmental fusion of the cervical vertebrae which is frequently associated with diverse non-osseous, e.g. neural, visceral, cardiopulmonary and genitourinary development anomalies. Anterior cervical meningocele (MMC) in KFS has only been described in two previous patients, both with non-surgical treatment.

Clinical presentation We present the case of a 26-year-old female suffering from KFS, presenting with progressive bilateral C6 paraesthesias, C7 and C8 motor weakness and myelopathy. Radiological imaging revealed incomplete osseous fusion of the vertebrae C2–Th1. The spinal cord was displaced ventro-caudally through a large anterior MMC, apparently fixed at the dorsal oesophagus, severely

stretching the cervical nerve roots. Surgery was indicated due to progression of the symptoms and was performed through a combined partial sternotomy and ventral anterolateral cervical approach. Intraoperatively, both division of oesophago-dural adhesions and intradural untethering of adhesions of the myelon with caudal parts of the cele were performed. Evoked somatosensory potentials improved immediately and 6-day postoperative MRI revealed a nearly complete reposition of the spinal cord in its physiological position. Genetic sequence analyses ruled out mutation of the growth and differentiation factor 6 (GDF6). Apart from slight intermittent paraesthesia, symptoms resolved almost completely within weeks after operation. Both radiological and neurological improvement remained stable at 16 months of follow-up.

Conclusion KFS with anterior cervical MMC is rarely seen and may require surgery in case of clinical signs of nerve root compression or myelopathy. Osseous decompression, untethering and adhesiolysis under electrophysiological monitoring can provide sufficient radiological and clinical improvement.

Keywords Klippel–Feil syndrome · Meningocele · Growth differentiation factor 6 · Operative surgical procedure

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Introduction

Klippel–Feil syndrome (KFS) is a rare mixed osseous and visceral development anomaly with an estimated incidence of 1/42,000 births. Although the aetiology still remains unclear, defects of the notochord and its signalling with insufficient separation of the cervical vertebrae are considered the main underlying cause [1]. Subsequently,

partial or complete fusion of two or more cervical vertebrae is the hallmark of KFS, usually associated with further osseous and non-osseous manifestations like low posterior hairline, brevicollis, basilar impression, atlanto-occipital fusion, scoliosis, facial asymmetry, torticollis, “Sprengel’s deformity” and other genitourinary, central nervous and cardiopulmonary anomalies. Neurological symptoms are infrequent (36 and 50 % in two studies) and include radiculopathy and myelopathy up to tetraparesis [1, 2]. Since hardly attributable to the fused vertebrae, symptoms are usually caused by spondylosis or instability of the segments neighbouring the fused vertebrae or by radicular compression within frequently undersized neuroforamina. In contrast to more frequently associated cranio-cervical development anomalies, e.g. microcephaly or syrinx, anterior cervical meningocele (MMC) is rarely observed and has only been described in two case reports and both patients were treated conservatively. To our knowledge surgical management has not been described yet [1–4].

We here report the case of a female patient with KFS-associated anterior MMC suffering from a sensomotory radiculopathy and subclinical signs of myelopathy which was treated by untethering.

Case report

In 2010, a 26-year-old female presented with 4-month history of progressive bilateral weakness and hypaesthesia of the hands. Klippel–Feil syndrome and anterior MMC had already been diagnosed about 7 years before due to intermittent nuchalgia. Due to the lack of symptoms of neural compression at the time of initial diagnosis, the patient was treated conservatively by physiotherapy only.

Neurological examination on the date of presentation revealed bilateral hearing impairment, headaches, pain in the neck and in both shoulders, a considerable reduced motion of the neck, symmetric C6 hypaesthesia and C7 and C8 motor weakness. Although weakness of the lower extremities was not detected, the patient showed hyperreflexia as a subclinical sign of myelopathy and dorsal column impairment as well as delayed evoked somatosensory potentials of the left tibial nerve. Cervico-thoracic radiographic imaging revealed incomplete ventral osseous fusion from C2 to Th1 and a MMC with a u-shaped ventral herniation of the myelon inside the dural sack and partial displacement of the oesophagus to the right. Besides distinct myelopathy, the cervical nerve roots appeared to be stretched between the spinal cord and the neuroforamina (Figs. 1a, 2, 3). Since the patient suffered from headache, four dimensional cranial MRI was performed to exclude hydrocephalus and showed only a small (2.5×1.3 cm)

left frontal arachnoidal cyst. As a consequence of progressive radicular symptoms and myelopathy, surgical treatment was advised to prevent further neurological deterioration.

Surgical technique

Surgery was performed ventrally through a partial sternotomy and via a ventral, anterolateral cervical approach (modified Smith and Robinson approach, 1955 [5, 6]) by a combined team of thoracic- and neurosurgeons. Intraoperatively, ventro-caudal parts of prolapsed spinal dura of the MMC appeared to be stretched down by a connective tissue fixation with the oesophagus at the level of Th5, presumably representing remnants of the misdeveloped notochord (Fig. 1a). After these adhesions were microsurgically divided, the MMC slipped back partially into the spinal channel. Next, the osseous defect associated with vertebral malunion was cranio-caudally enlarged to reduce compression of the herniating parts of the spinal cord. After incision of the dura, caudal parts of the prolapsed spinal cord appeared to be adhered to the inner dura and were subsequently untethered under neurophysiological monitoring. Somatosensory evoked potentials were found to have improved immediately after untethering.

Preoperative radicular symptoms improved within the first days after surgery. A MRI obtained 6 days after surgery showed the spinal cord to have almost completely returned to a physiological position (Fig. 1b). On 6- and 16-months follow-up, pareses and neck pain had totally resolved and persisting symptoms were limited to an intermittent, slight paraesthesia of the left hand. In addition, evoked somatosensory potentials recovered completely. The radiological shape of the thecal sack and the spinal cord remained unchanged during 6- and 16-month follow-up (Fig. 1c, d). For scientific reasons, mutations of the growth and differentiation factor 6 (GDF6) gene locus were ruled out by genetic sequence analyses.

Discussion

Meningomyelocele (MMC) is considered the most common neural tube defect. Although possible at any level of the vertebral column, MMC usually affects the dorsal parts of the lumbosacral spine segments [1, 7]. Thus, anterior cervical MMC in KFS is a very rare condition with only two previously published case reports so far. In contrast to our case, surgical treatment was not performed in either case [3, 4].

In 2009, Balachandran [3] reported the case of a 36-year-old female presenting with bilateral atrophy of the intrinsic hand muscles. MRI revealed fusion of the cervical

Fig. 1 Sagittal, T2-weighted non-contrasting MRI (a–d) showing the ventral cervical MMC and multiple vertebrae fusions characteristic for KFS (a). Images b–d illustrate sufficient adhesiolysis and subtotal reposition of the spinal cord with postoperative fluid remnants on

MRI 6 days after surgery (b). The size of the thecal sack and the position of the spinal cord remained unchanged on 6- and 16-months follow-up MRIs (c and d T2-weighted non-contrast MRI)

Fig. 2 Preoperative sagittal, T2-weighted non-contrasting MRI demonstrating stretched cervical nerve roots (*asterisk*) due to ventral malposition of the spinal cord as part of the MMC

vertebrae and neural arches and anterior meningocele at the level of C6 and C7. On T2-weighted sagittal images, according to a cervical MMC, the spinal cord was flexed anterior inside the thecal sac and at least partially removed from the spinal canal to the level of the vertebrae bodies. Unfortunately, treatment was not described in this case. In 2012, Jiang et al. reported a second case of an anterior cervical MMC in KFS. The authors describe a 23-year-old female patient also presenting with bilateral weakness of the hands. As in the first case, spinal sagittal MRI showed anterior MMC at the level of C6 and C7 with kinking and prolapsing of the spinal cord into the ventrally enlarged thecal sac. 3D-reconstructed CT-scans of the spine demonstrated fusion of multiple lower cervical vertebrae. MRI showed asymptomatic intracranial development anomalies like hydrocephalus, enlargement of the

Fig. 3 Axial (a) and coronal (b) preoperative post-myelography CT illustrates the ventral vertebral defect with the prolapsing thecal sack (a + b) and osseous fusions from C2 to TH1 (b)

fourth ventricle, the posterior fossa and the subarachnoid space as well as thinning of the genu and trunk of the corpus callosum. Since neurological symptoms had been progressive for few weeks, surgical treatment was advised to prevent further neurological deterioration. The patient refused surgery and conservative treatment was performed using a hard neck collar. The neurological status was described as unchanged after 4 months of follow-up [4]. Comparing these cases, neurological symptoms as well as radiological imaging appeared to be very similar in all three patients and surgery was indicated at least in two of them.

Similar to previously published reports, the presented case is assumed as a very rare form of a split notochord syndrome, caused by a development disorder during gastrulation. During the third week of embryogenesis, the anteriorly lying ectoderm is gradually divided from the posteriorly lying entodermal layer by interposition of the newly developing mesoderm. Anterior migrating and

proliferating cells from the mesodermal layer generate the notochord process, a precursor of the subsequently evolving notochord. In split notochord syndrome, persisting tissue adhesions between the entoderm and the ectoderm are assumed to prevent the complete closure of the notochord, inducing insufficient development of the vertebrae bodies in subsequent ontogenesis [1, 8]. Initially described by Maurice Klippel and Andre Feil, multiple classification systems have been proposed, based on radiographic appearance, neurological symptoms, genetic alterations and intersegmental mobility [9]. Regarding the classification of Klippel and Feil, subtypes include Type I with multiple fused cervical and upper thoracic vertebrae, Type II with fusion of only one or two intervertebral cervical spaces and Type III with both vertebral fusions of the cervical and lumbar or lower thoracic spine [1, 10]. Accordingly, KFS in our case could be classified as Type I.

Together with GDF5 and 7, GDF6 is a member of a subgroup of bone morphogenetic proteins and involved in cell–cell interaction as well as in cell and tissue differentiation in joints, ligaments and cartilage [11]. Expressed in vertebrae and within the adult intervertebral disc [12], lack of GDF6 and GDF5 in mice was shown to induce osseous malformations along the vertebral column and mutations in the GDF6 gene locus have been described in both familial and sporadic cases of KFS [11, 12]. Nevertheless, reports about KFS patients lacking mutations of the GDF6 locus suggest other underlying genetic alterations [13]. Similarly, sequence analyses revealed no mutation of the GDF6 gene locus in our patient which was not examined in the two previously published cases.

Conclusion

KFS with an anterior cervical MMC is considered a very rare condition which requires surgery in case of signs of myelopathy or progressive neurological impairment. Besides osseous decompression, surgery should aim to untether intradural adhesions as well as adhesions between the thecal sac and extraspinal structures. Neurophysiological monitoring is helpful during surgery and in our case confirmed sufficient untethering. Although reported in sporadic and familial cases, GDF6 mutations are irregularly observed in KFS.

Conflict of interest None of the authors has any potential conflict of interest.

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