

Chiari Malformation Decompression without Instrumentation

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ABSTRACT

Chiari I malformations are the most common anomalies of the craniocervical junction. Many surgical techniques have been recommended, but the optimal treatment strategy for these patients is still under debate. In this report, we describe the surgical steps for posterior fossa decompression we usually perform at our department.

The surgical technique is demonstrated in three cases of children with Chiari malformation Type I. Posterior fossa decompression was achieved by decompressive suboccipital craniectomy, C1 laminectomy, and duraplasty. Cerebellar tonsil resection was performed to obtain visualization of the obex and arachnoid membranes were removed to preserve an unimpaired cerebrospinal fluid (CSF) circulation.

The children all had good and very good postoperative clinical results. Remarkable improvement of neurological deficits was observed and radiological benefit was documented.

In our opinion, the described strategy is an effective way to achieve decompression of the craniocervical junction and to restore normal CSF dynamics. Good and very good postoperative results could be documented, but optimal treatment management will still be a matter of debate.

KEY WORDS: Chiari malformation, C1 laminectomy, duraplasty, posterior fossa decompression

INTRODUCTION

Chiari malformation Type I is the most common type of anomaly of the craniocervical junction. This condition is characterized by caudal herniation of the cerebellar tonsils > 5mm below the level of the foramen magnum (2,9,18). It is typically associated with syringomyelia in 30-85% of the cases (4,7,9,15,18). Other common findings are scoliosis (12-57%), basilar invagination (12-27%), and hydrocephalus (3-10%) (6,9,15,18). Radiological examinations also have revealed a smaller and narrower posterior fossa in patients with Chiari malformations than in the normal population (9,20,25). These anatomical anomalies cause a disturbance in CSF dynamics at the craniocervical junction. In most of the cases, compression of CSF spaces lateral and posterior to the cerebellum is found on magnetic resonance imaging (MRI) (18) and the physiological flow between the cerebral and spinal subarachnoid spaces is obstructed by the herniated tonsils (21).

Prevalence of Chiari malformation Type I was described as between 0.56% (7) and 0.77% (17), but there is a large increase in the diagnosis of herniated tonsils, due to recent advantages in neuroimaging techniques and their increasingly frequent use (5,9). A female predominance is observed (4,5,7,9,10,12).

Symptoms onset usually occurs in the second or third decade (9,10), but can occur at any age, ranging from one year to older than 60 years (3,6,11,12,27). Patients typically complain about head and neck pain worsening with Valsalva maneuvers, dizziness/vertigo, ataxia, motor weakness, sensory disturbances, ocular symptoms (blurred vision, diplopia or photophobia), lower cranial nerve palsies, tinnitus, breathing-related sleep disorders, and developmental delay (6,9,22,23,26). However, in some cases, patients with this malformation remain asymptomatic.

Surgical treatment should be considered in symptomatic patients, but should not be considered in patients without any

symptoms and without syringomyelia. There are different opinions on whether or not asymptomatic patients with Chiari malformation Type I and associated syringomyelia should be considered as candidates for surgery (8,9,24).

Overall, symptoms and signs resolved or improved postoperatively in 75-91.8%, (4,6,8,14,15), and no remarkable changes in clinical findings after surgery could be detected in 8-21.6% (6,8,14) of the patients. A poor outcome with deterioration was observed in 6-13.3% of the cases (6,8). Postoperative radiological examinations revealed a remarkable decrease in syringomyelia size in most of the patients (66-78%) (4,10,15).

Typical complications after surgery in Chiari I malformations include CSF leakage, aseptic or bacterial meningitis, postoperative hemorrhage, wound infections, recurrence, pseudomeningocele, and neurological deficits with a clear dominance of CSF complications (4,8,22). Surgery-related mortality occurred in 0-3% (4,6,13,15,22).

The main goals of surgical treatment are relieving posterior fossa compression and restoring normal CSF dynamics to the craniocervical junction. Many surgical techniques have been recommended, but the optimal management of patients with Chiari malformations Type I is still under debate, especially the optimal extent of bone resection, the use of duraplasty, and the need for tonsillar reduction and arachnoid dissection (24). In this report, we describe the surgical method we usually perform in cases of Chiari I malformations at our department.

METHODS

Surgical technique is demonstrated in three cases of children with Chiari malformation Type I who underwent

posterior fossa decompression surgery at the Department of Neurosurgery, Saarland University Medical Center, Homburg/Saar, Germany.

CLINICAL PRESENTATION

Case 1

The five-year-old boy presented with headache, developmental delay, coordination deficits especially ataxia, and upper extremity weakness. MRI revealed Chiari malformation Type I with tonsillar herniation 14 mm below foramen magnum associated with an increasing cervical syringomyelia with an extent of 10 x 8 x 6 mm (Figure 1.1).

Case 2

The six-year-old girl presented with headache, tinnitus and scoliosis. Tonsillar herniation below the level of foramen magnum, an extended syrinx from cervical to thoracolumbar spinal cord, thoracic scoliosis, and CSF disturbance at the craniocervical junction were shown on MR images (Figure 2.1).

Case 3

The nine-year-old boy presented with spinal ataxia, dizziness, paresthesia of both hands, and severe head and neck pain. MRI revealed herniation of the cerebellar tonsils below foramen magnum and an associated syringomyelia with an axial size of 4 x 8 mm extending the whole spinal cord (Figure 3.1).

SURGICAL TECHNIQUE

Surgeries were performed under general anesthesia, using a microsurgical technique, with intraoperative support of a neuronavigation device, and under electrophysiological



Figure 1.1: Preoperative imaging in case of a five-year-old male patient. A,B) Sagittal T2-weighted MR image showing tonsillar herniation 14 mm below the foramen magnum and cervical syringomyelia. C) Cervical syringomyelia on axial T2-weighted MR image.

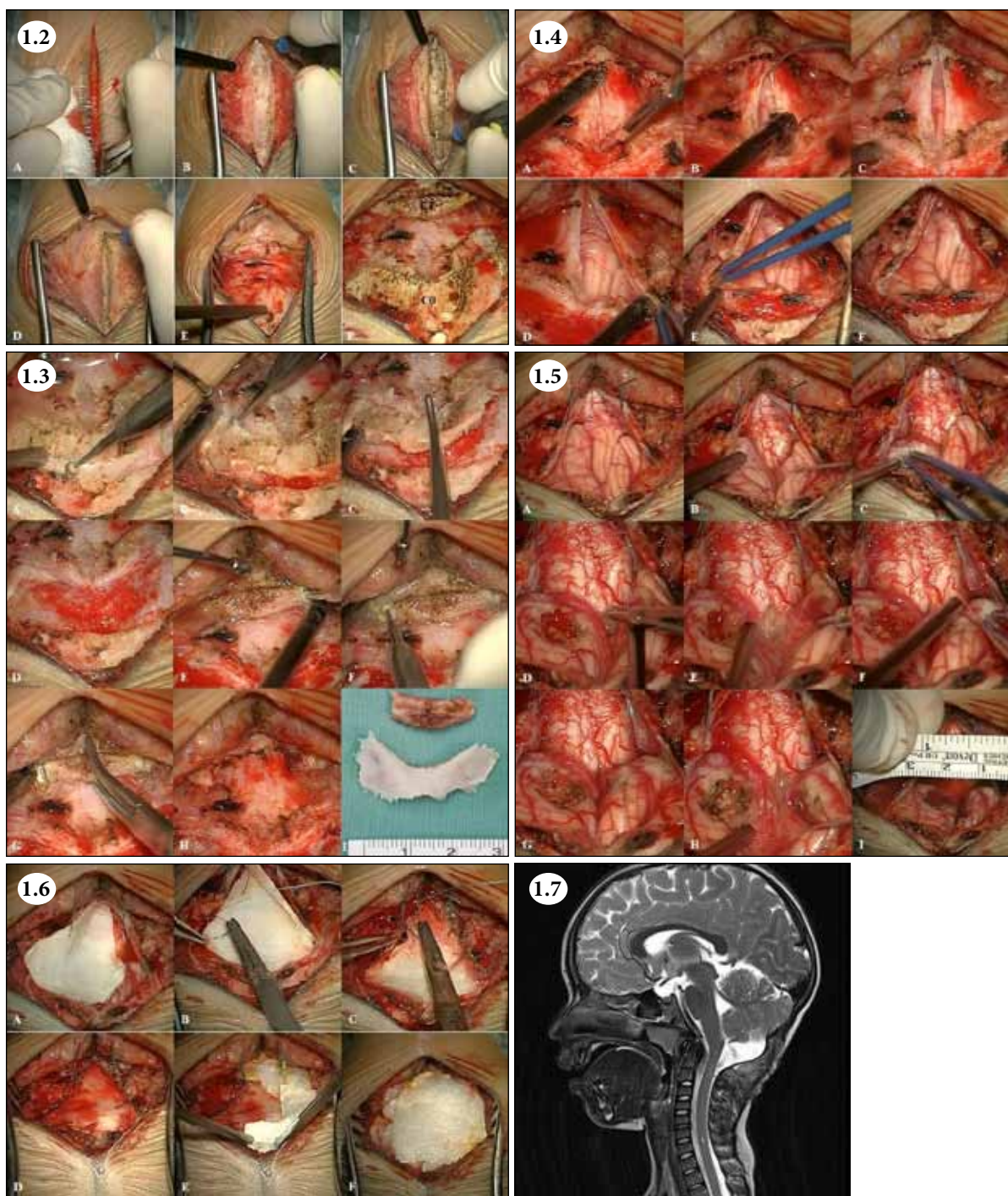


Figure 1.2: Intraoperative preparation to obtain exposure of the craniocervical junction. Skin incision (A) and division of the skin (B) and muscle layers (C, D) using a monopolar device. View of the bony structures (C1: posterior arch of the atlas, C0: occipital bone at the level of the foramen magnum) (E, F).

Figure 1.3: Decompressive suboccipital craniectomy and C1 laminectomy. A-C) Removal of the suboccipital bone segment. D) View after removal. E-G) C1 laminectomy. H) View after laminectomy. I) Removed occipital bone segment (below) and C1 arch (above).

Figure 1.4: Dura opening in a Y-shaped manner (A-D) and bipolar coagulation to stop dural bleedings (E). View after dura opening (F).

Figure 1.5: Tonsillar resection and obex opening. A) View of the tonsillar malformation after dura opening and arachnoid dissection. The right cerebellar tonsil is larger than the left one and extending to the C2 arch. B) Obex is not visible and covered by the tonsils. C) Coagulation of the right cerebellar tonsil. D, E) Obex exposure and arachnoid membrane resection. F) Partial resection of the left tonsil. G, H) Inspection after tonsil and arachnoid membrane resection. I) Extent of surgical field size.

Figure 1.6: Duraplasty with a rhomboid piece of allogeneic fascia lata fixed with single interrupted sutures (A-D) and additional sealing using tissue-glue-coated collagen sponge (E, F).

Figure 1.7: Postoperative sagittal T2 weighted MR image four months after decompression showing a remarkable decrease in syrinx size.

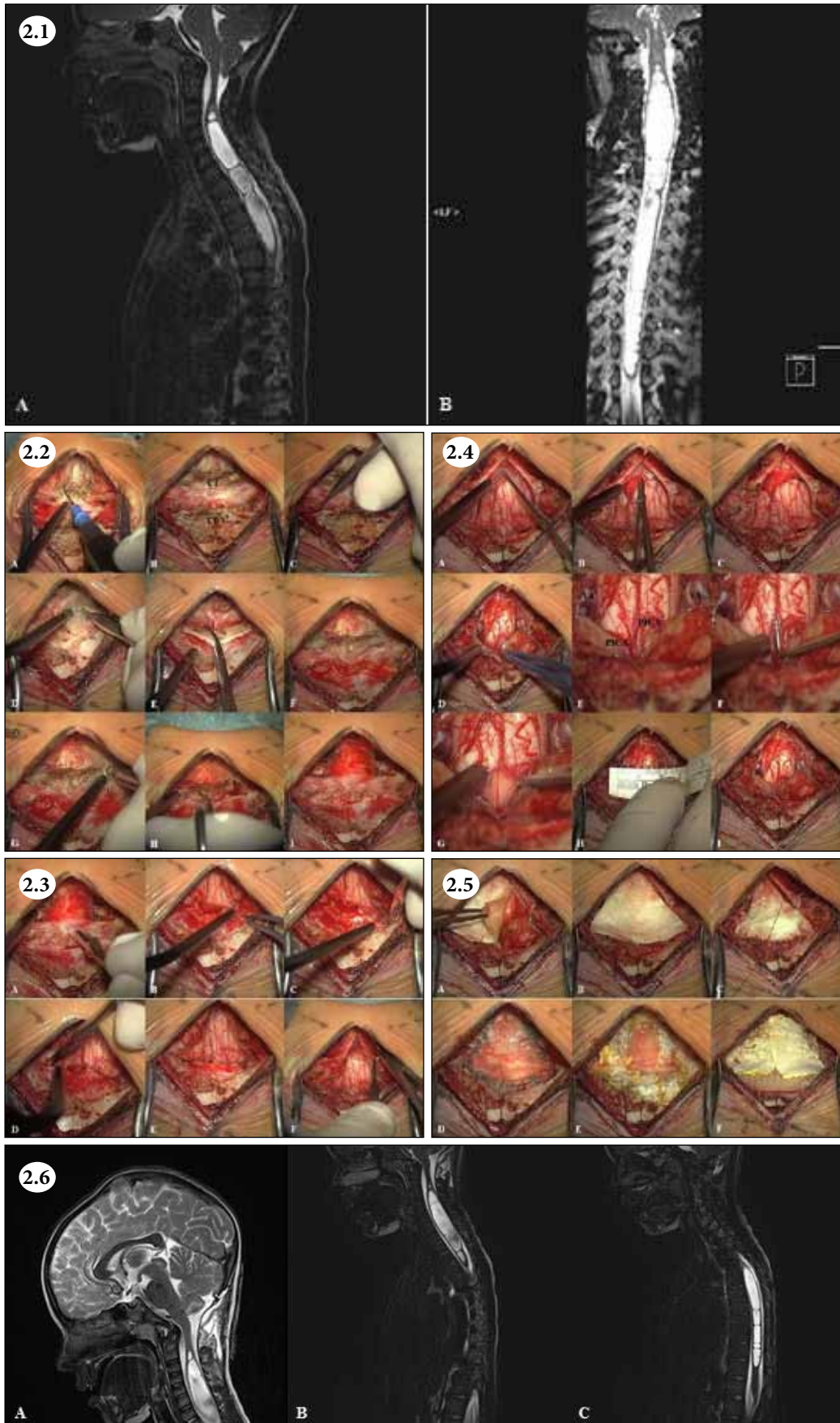


Figure 2.1: Preoperative MRI in case of a six-year-old girl. Sagittal T2-weighted image showing tonsillar herniation below the level of the foramen magnum as well as the cervical and thoracic part of the syrinx (A) and coronar T2 weighted image showing syrinx extent from cervical to thoracolumbar spinal cord and thoracic scoliosis (B).

Figure 2.2: Decompressive suboccipital craniectomy and C1 laminectomy. A) Intraoperative preparation to obtain exposure of the bony structures of the craniocervical junction. B) View of the bony structures (C1: posterior arch of the atlas, C0: occipital bone at the level of the foramen magnum). C) Application of neuronavigation. D, E) Removal of the suboccipital bone segment. F) View after removal. G, H) C1 laminectomy. I) View after laminectomy.

Figure 2.3: Y-shaped dura opening with bipolar coagulation to stop dural bleedings (A-E) and performing a dural tenting suture (F).

Figure 2.4: CSF flow restoration. A, B) Arachnoid dissection. C) Exposure of the herniated cerebellar tonsils, obex is not visible and covered by the tonsils. D) Coagulation of the cerebellar tonsils. E) Exposure of the vascular structures (VA: vertebral artery, PICA: posterior inferior cerebellar artery). F, G) Arachnoid membrane resection and obex exposure. H) Extent of surgical field size. I) View after tonsil and arachnoid membrane resection.

Figure 2.5: Duraplasty with a rhomboid piece of allogeneic fascia lata fixed with single interrupted sutures (A-D) and additional sealing using tissue-glue-coated collagen sponge (E, F).

Figure 2.6: Postoperative sagittal T2 weighted MR images one week after decompression showing good postoperative result at the craniocervical junction (A) and a slight but no remarkable change in syrinx size (B, C).

monitoring. The patients were placed in a prone position with their head fixed by a Mayfield skull clamp. A Mayfield clamp is used from 2 years of age onwards, whereas in younger patients the head is fixed with circular bandages. After preoperative preparations, a median skin incision extending from the level of C2 to the occiput was done. The skin and muscle layers were divided using a monopolar device, and the neck musculature was moved aside to obtain exposure of the craniocervical junction area (Figures 1.2, 2.2A-C, 3.2A).

A decompressive suboccipital craniectomy extending about 30x15mm was performed. As a rule of thumb, the C0-C1 joint should be reached on both sides. In the authors' view, the extent of decompression cranially is considered not to be so important. A wide posterior decompression rather than a large cranio-caudal decompression is the goal. After decompression, a C1 laminectomy was done additionally to achieve adequate decompression (Figures 1.3, 2.2D-I, 3.2B-I).

Dural opening in a Y-shaped manner followed. Bleedings from dural margins were stopped by bipolar coagulation (Figures 1.4, 2.3) and dural tenting sutures were placed (Figure 3.3). Particularly the opening of the dura is one of the very few but crucial steps in this procedure. A large persisting sinus suboccipitalis might cause rapid high-volume blood loss, particularly in young children. Thus, a step by step opening of the dura of the posterior fossa is recommended. If a safe and blood loss-sparing opening is not possible, posterior decompression while preserving the integrity of the dura might be another option (see discussion). After dural opening, the herniated cerebellar tonsils were displayed. In all cases, a noticeable tonsillar malformation was shown (Figures 1.5, 2.4, 3.4). The obex region was not visible and assessable due to the abnormal anatomical situation and the decision for tonsillar resection was made in all cases (Figures 1.5B, 2.4D, 3.4A-D). During tonsillar resection, particular care was given to vascular structures located in this region, especially the posterior inferior cerebellar artery (PICA). Now, the tonsils were mobilized, the obex could be visualized, and an arachnoid membrane closing its aperture was revealed. Arachnoid membranes and adhesions in the tonsillar surrounding were removed, and unimpaired CSF circulation was preserved (Figures 1.5H, 2.4F-I, 3.4E+F).

After hemostasis, a duraplasty with enlargement of the posterior fossa using commercially available dural substitute was performed. The rhomboid piece of dural substitute was

fixed with single interrupted sutures and a watertight closure was achieved. This was confirmed by Valsalva's maneuver. For additional sealing and tissue stabilization a tissue-glow-coated collagen sponge was inserted (Figures 1.6, 2.5, 3.5). A secure hemostasis was achieved and adaptive suturing of the muscle, subcutaneous and skin layers followed. The closed wound was covered by a sterile dressing. After surgery, the children were extubated and observed on a pediatric intensive care unit (ICU).

RESULTS

Case 1

The boy showed very good postoperative clinical results. Improvement of neurological deficits was observed, especially in muscular weakness, coordination deficits, and headache. A collection of CSF in the region of the surgical approach was revealed on MRI, but showed regression under observation and no surgical treatment was necessary. Postoperative MRI four months after surgery documented a remarkable decrease in syringomyelia size (Figure 1.7).

Case 2

Postoperatively, the girl presented with good clinical results except a CSF fistula that showed regression after performing an additional suture. Especially in headache and tinnitus, noticeably clinical improvement could be documented. MRI one week after decompression showed a slight but at this time not remarkable decrease in syrinx size and an undisturbed CSF flow at the craniocervical junction (Figure 2.6). As the patient returned to the United States, no follow-up could be conducted at our department.

Case 3

After surgical decompression, very good clinical results could be documented. Remarkable improvement in symptoms was observed, especially in head and neck pain, as well as in paresthesia. No CSF collection or fistula was found. Postoperative MRI revealed a relevant decrease in syrinx size five months after surgery (Figure 3.6).

DISCUSSION

Chiari malformation Type I is characterized by caudal tonsillar herniation > 5mm below the level of the foramen magnum. It is the most common type of anomaly located at the craniocervical junction (2, 9, 18). It is typically associated with other conditions, such as syringomyelia (30-85%), scoliosis (12-57%), basilar invagination (12-27%), and hydrocephalus (3-10%) (4, 6, 7, 9, 15, 18). In patients with Chiari malformation Type I, radiological examinations

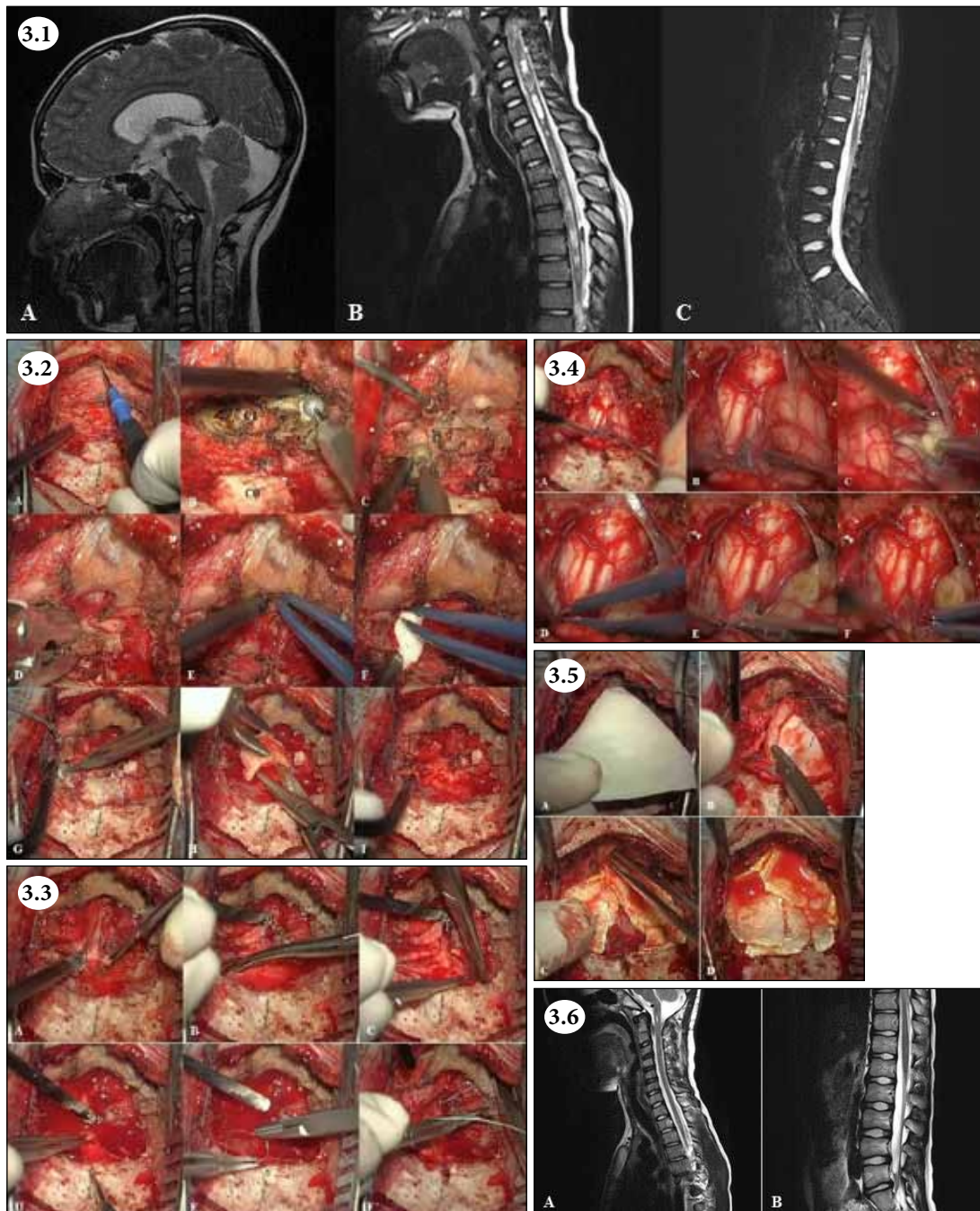


Figure 3.1: Preoperative imaging in case of a nine-year-old male patient. **A)** Sagittal T2-weighted MR image showing tonsillar herniation below the foramen magnum. **B)** Sagittal T2-weighted MR image showing cervical and thoracic extent of the syrinx. **C)** Thoracolumbar part of the syrinx in sagittal T2 weighted MR image.

Figure 3.2: Decompressive suboccipital craniectomy and C1 laminectomy. **A)** Intraoperative preparation to obtain exposure of the bony structures of the craniocervical junction. **B-D)** C1 laminectomy (C1: posterior arch of the atlas, C0: occipital bone at the level of the foramen magnum). **E, F)** Hemostasis by bipolar coagulation and insertion of a gelatin sponge. **G, H)** Removal of the suboccipital bone segment. **I)** View after removal.

Figure 3.3: Dura opening and dural tenting suture. **A-C)** Y-shaped dura opening. **D)** Drilling of a hole for a dural tenting suture at the occipital bone. **E, F)** Performing dural tenting sutures.

Figure 3.4: CSF flow restoration. **A)** Arachnoid dissection. **B)** Inspection of the obex region reveals arachnoid membranes and layers. **C, D)** Tonsillar shrinking by bipolar coagulation. **E)** Opening and removal of membranes closing the obex aperture. **F)** Inspection after opening the obex region.

Figure 3.5: Duraplasty with a rhomboid piece of allogeneic fascia lata fixed with single interrupted sutures (**A, B**) and additional sealing using tissue-glue-coated collagen sponge (**C, D**).

Figure 3.6: Postoperative sagittal T2 weighted MR images one week after surgery showing good postoperative result at the craniocervical junction after decompression (**A**) and revealed a relevant decrease in syrinx size (**B**).

have also revealed a smaller and narrower posterior fossa than in the normal population (9, 20, 25). These anatomical anomalies lead to disturbances in CSF dynamics at the craniocervical junction. In most of the cases, compression of CSF spaces lateral and posterior to the cerebellum is found on MRI (18), and herniated tonsils obstruct physiological flow between the cerebral and spinal subarachnoid spaces (21). The main goals of surgery are posterior fossa decompression and reconstitution of CSF pathways.

Many different surgical techniques have been recommended, but the optimal management of patients with Chiari malformation Type I still remains under debate, especially the optimal extent of bone resection, the use of duraplasty, and the need for tonsillar reduction and arachnoid dissection.

Extent of Bony Removal

Regarding the current literature, suboccipital craniectomy and C1 laminectomy for foramen magnum decompression are essential procedures in posterior fossa decompression and standard surgical procedures for Chiari malformation Type I treatment (4, 8, 12, 15, 16, 19, 22, 26). Some authors suggest laminectomy according to the tonsillar descent and also perform additional C2 (and C3) laminectomy in special cases (10, 14, 22). *Kumar et al.* demonstrated the importance of complete C1 laminectomy to relieve compression of the structures located at the craniocervical junction in a case report. An inadequately performed C1 laminectomy and

only partially removed C1 arch may result in residual compression at the level of the craniocervical junction, remaining symptoms or symptoms recurrence, and need for re-surgery. So, they see C1 laminectomy as a keystone in posterior fossa decompression surgery (16). An overview of literature about craniectomy size and C1 arch removal is listed in Table 1 and 2.

We usually perform a suboccipital craniectomy in combination with a C1 laminectomy in every case of surgically treated adult and pediatric patients with Chiari malformation Type I. In our opinion, adequate bony decompression can only be achieved by extending the bone removal from foramen magnum decompression to C1 laminectomy. We recommend a craniectomy extending from one C0-C1 joint to the other one. In our opinion, the extent of cranial decompression is considered not to be of particular importance. So, a wide posterior decompression rather than a large cranio-caudal decompression is the goal. An isolated suboccipital craniectomy would not relieve compression of the caudally herniated cerebellar tonsils adequately. In selected cases, an additional C2 laminectomy might be required.

Duraplasty

Whether to perform a duraplasty or not is the most discussed topic concerning the optimal surgical treatment of patients with Chiari I malformation. Posterior fossa decompression with duraplasty is seen by some authors

Table 1: Craniectomy Size – an Overview of Literature

Author	No of Patients	Children/Adults	Bone Removal
Erdogan et al. (2010) ⁸	n=27	Both	Decompressive suboccipital craniectomy, at least 3 cm above foramen magnum, width of 3 cm
Gurbuz et al. (2015) ¹²	n=39	Both	Decompressive suboccipital craniectomy, at least 3 cm above foramen magnum, width of at least 4 cm
Kennedy et al. (2015) ¹⁵	n=156	Children	Suboccipital craniectomy
Kumar et al. (2014) ¹⁶	n=1	Adults	Suboccipital craniectomy
Mutchnick et al. (2010) ¹⁹	n=121	Both	Wide suboccipital craniectomy
Rehman et al. (2015) ²²	n=21	Adults	Suboccipital craniectomy
Furtado et al. (2011) ¹⁰	n=20	Children	Midline suboccipital craniectomy, individualized according to age
Hoffman and Souweidane (2008) ¹⁴	n=40	Both	Suboccipital decompression, superior extension of approximately 1.5-2.0 cm, lateral extension to the lateral-most aspect of the foramen magnum and cervical spinal canal

to be the best treatment option because of symptomatic improvement and low rates of complications. Confirming the absence of CSF leaks by Valsalva maneuver before wound closure is suggested (22).

Erdogan et al. found no statistically significant difference between duraplasty and non-duraplasty group, either in the postoperative symptoms and signs or in syrinx regression. They recommended dura opening in cases where the surgeon has any suspicions about maintaining CSF flow in the posterior fossa, e.g. if there is no visible pulsation in cases of thick fibrotic dura (8). *Abla et al.* argue that duraplasty is essential for successful surgery in patients with Chiari malformation Type I because of creating an artificial cisterna magna where one was not previously present (1). Other authors find the dura flexible enough to build a cisterna magna in the first three month after surgery if bony decompression was adequate (8). *Kennedy et al.* recommend a non-dural opening decompression for the majority of children with a symptomatic Chiari malformation Type I (15).

In one study, there was a significantly higher rate of regression in postoperative syrinx size in patients treated with foramen magnum decompression and duraplasty than without duraplasty (12). Posterior fossa decompression without duraplasty is associated with a slightly higher rate of recurrent symptoms requiring repeated decompression (19).

On the other hand, there are significantly longer operating durations and hospital stays (8, 19) and not significantly higher complication rates in cases of duraplasty (12). An overview of the literature on duraplasty in posterior fossa decompression surgery is shown in Table 3.

In posterior fossa decompression surgery, we see some advantages in opening the dura and usually perform a duraplasty in every case. After opening the dura at the level of foramen magnum, intradural structures can be inspected. The extent of tonsillar herniation can be visualized, tonsils can be mobilized, the need for tonsil shrinkage can be evaluated and arachnoid adhesions and membranes can be found and resected. Besides, CSF flow at the craniocervical junction can be assessed. If it is found to be indicated, CSF flow can be restored by tonsil shrinkage or arachnoid dissection. In our opinion, adequate posterior fossa decompression is not only achieved by bony removal, but also by additional duraplasty and creating an artificial cisterna magna.

Tonsillar Resection

Tonsillar resection is more common during surgery on pediatric than in adult patients (4). *Guyotat et al.* reported a better outcome in patients with Chiari I-related syringomyelia treated by foramen magnum decompression and additional tonsil resection than those treated using other additional modalities (13).

Table 2: C1 Arch Removal – An Overview of Literature

Author	No of Patients	Children/Adults	C1 Arch Removal
Erdogan et al (2010) ⁸	n=27	Both	Total C1 laminectomy (removal of the atlantooccipital ligament and dural scarring or bands on the dura outside)
Gurbuz et al. (2015) ¹²	n=39	Both	Total C1 laminectomy
Kennedy et al. (2015) ¹⁵	n=156	Children	Total C1 laminectomy and incision of the atlantooccipital ligament in all cases; additional C2 partial laminectomy in 12 cases
Kumar et al. ¹⁶	n=1	Adults	C1 laminectomy (3 cm wide)
Mutchnick et al. (2010) ¹⁹	n=121	Both	Total C1 laminectomy and careful resection of dural bands
Rehman et al. (2015) ²²	n=21	Adults	C1 laminectomy in all cases, additional C2 laminectomy in 2 cases
Furtado et al. (2011) ¹⁰	n=20	Children	C1 laminectomy in all cases, additional C2 laminectomy in 1 case
Hoffman and Souweidane (2008) ¹⁴	n=40	Both	Extent of cervical laminectomy determined by degree of tonsillar descent

At our department, we reduce or resect cerebellar tonsils if it is found to be necessary. After dura opening, the surgeon accurately inspects the intradural structures and their surroundings. In many cases, especially in pediatric patients, the herniated tonsils obstructed the flow between the cerebral and spinal subarachnoid spaces and cover the

obex region. Tonsil resection can be achieved by bipolar coagulation to restore normal CSF flow and to enable inspection of the obex region.

Arachnoid Dissection

Erdogan et al. see one advantage of arachnoid dissecting in

Table 3: Duraplasty – An Overview of Literature

Author	No of Patients	Children/ Adults	Material	Results
Abla et al. (2010) ¹	Review of literature	Both	Autologous and nonautologous	Duraplasty essential because of creating a cisterna magna where one was not previously present; no superiority of neither autologous nor nonautologous graft; pericranium is preferred if possible
Erdogan et al. (2010) ⁸	n=27 (15 FMD with duraplasty, 12 only FMD)	Both	“Y”-shaped opening and dural grafting with cadaveric dura	No statistical postoperative differences à dura opening recommended in cases of any suspicion about maintaining CSF flow in the posterior fossa
Gurbuz et al. (2015) ¹²	n=39 (21 duraplasty, 18 non-duraplasty)	Both	n.n.	No statistically significant difference for surgical results, but in regression of postoperative syrinx size à in patients with syrinx, tonsillar herniation greater than 10 mm, and symptom duration less than 36 months, duraplasty considered to be a more reliable choice despite a slightly higher rate of complications
Hoffman and Souweidane (2008) ¹⁴	n=40	Both	Autologous pericranial tissue	PFD with duraplasty is safe and appropriate
Kennedy et al. (2015) ¹⁵	n=156 (non-duraplasty)	Children	n.n.	Dura opening recommended for patients with rapid progression of neurological deficits, scoliosis with syrinx, craniocervical instability requiring fusion, and if preoperative MRI suggests that partial C2-laminectomy will be necessary
Mutchnick et al. (2010) ¹⁹	n=121 (56 non-duraplasty, 64 duraplasty)	Both	Y-shaped incision extending caudal past the foramen magnum with a generous pericranial patch, covered with Tisseal	Clear benefits to the majority of children without duraplasty, but recurrence is slightly higher than with duraplasty
Rehman et al. (2015) ²²	n=21	Adults	n.n.	PFD with duraplasty best treatment option
Furtado et al. (2011) ¹⁰	n=20	Children	with pericranium or artificial dura	PFD with duraplasty preferred

FMD: Foramen magnum decompression, **PFD:** Posterior fossa decompression.

Table 4: Tonsillar Resection with Arachnoid Dissection – An Overview of Literature

Author	No of Patients	Children/Adults	Performed Procedures
Erdogan et al. (2010) ⁸	n=27	Both	Opening of thick arachnoid layers and resection of thick arachnoid bands between the tonsils can be necessary to obtain CSF passage
Furtado et al. (2011) ¹⁰	n=20	Children	Dense subarachnoid bands were released and tonsils were shrunk with bipolar cautery until free egress of CSF was seen from the foramen of Magendie
Guyotat et al. (1998) ¹³	n=75	Both	Better outcome in patients treated by PFD and additional tonsil resection

releasing adhesions that potentially obstruct CSF flow from the fourth ventricle to the spinal canal. In their opinion, the arachnoid layer has to be opened in cases of thick layers and arachnoid bands to visualize CSF flow between the tonsils (8). Table 4 shows an overview of literature about tonsillar resection and arachnoid dissection.

We found arachnoid dissection useful and necessary in most of the cases. After opening the dura and inspection the intradural structures, arachnoid membranes and adhesions that seem to impair the normal CSF dynamics are common findings. In these cases, we perform resection of membranes and adhesions until CSF flow is obtained.

CONCLUSIONS

Posterior fossa decompression by suboccipital craniectomy, C1 laminectomy, and duraplasty in combination with tonsillar resection and arachnoid dissection, if it is found to be necessary, is the usual way of surgical treatment in patients with Chiari I malformation at our department. In our opinion, it is an effective strategy to achieve decompression at the craniocervical junction and to restore normal CSF dynamics. Good and very good postoperative results could be documented, but optimal treatment management will still be a matter of debate.

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