RESEARCH ARTICLE / *Araştırma Makalesi*

Development and Treatment of CSF Fistula, Post-Operative Headache, Cerebellar Ptosis In 62 Patients Who Underwent Posterior Fossa Cranioplasty or Not Following Posterior Fossa Surgery

Posterior Fossa Cerrahisinde Kraniyoplasti Yapılan Ve Yapılmayan 62 Hastada BOS Fistülü, Postoperatif Baş Ağrısı, Serebellar Pitozis Gelişimi Ve Tedavisi

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Abstract

Introduction	The approaches in posterior fossa surgery are used for accessing various tumors and vascular lesions including neuro-glial tumors, vestibular Schwannomas, inclusion tumors, meningiomas.
Materials and Methods	A total of 62 patients who underwent operation due to infra-tentorial intra-cranial mass lesion in Neuro-Surgery Clinic between 2014 and 2018 were included in the study.
Results	The study was conducted with 62 patients of whom 61.3% (n=38) were males and 38.72% (n=24) were females between 2014 and 2018. While 33.9% (n=21) of the patients underwent cranioplasty, 66.1% (n=41) did not undergo cranioplasty.
Conclusion	The preliminary study suggests that cranioplasty is useful for headache and cerebellar ectopy however insufficient for prevention of CNF fistula development.
Keywords	posterior fossa; cranioplasty; cerebro-spinal fluid fistula; post-operative headache; cerebellar ptosis

Öz

Amaç	*Posterior fossa cerrahi yaklaşımları nöro-glial tümörler, vestibüler Schwannomlar, inklüzyon tümörleri, meningiomlar gibi çeşitli tümörlere ve vasküler lezyonlara ulaşmak için kullanılmaktadır*
Yöntem ve Gereçler	*2014-2018 yılları arasında Nöroşirürji Kliniği'nde infratentoryal intrakranial kitle lezyonu nedeniyle opere edilen toplam 62 hasta çalışmaya dahil edildi.*
Bulgular	*Çalışma 2014-2018 yılları arasında %61,3 (n=38) erkek ve %38,72 (n=24) kadın olmak üzere 62 hasta ile gerçekleştirildi. Hastaların %33,9'una (n=21) kraniyoplasti yapılırken, 66,1 % (n=41) kranyoplasti geçirmedi.*
Sonuç	*Bizim bu çalışmamız, kranioplastinin baş ağrısı ve serebellar ektopi için yararlı olduğunu ancak BOS fistül gelişimini önlemede yetersiz olduğunu düşündürmektedir.*
Anahtar Kelimeler	*Posterior fossa; kranioplasti;beyin omurilik sıvısı fistül; ameliyat sonrası baş ağrısı; serebellar ptoz*

INTRODUCTION

Incidence and location of intra-cranial tumors vary depending on age. Intra-cranial tumors are located in supra-tentorial region in the ratio of 75% in adults and in infra-tentorial region in the ratio of 70% in children. Posterior fossa tumors lead to elevated intra-cranial pressure due to circulation disorders of cerebro-spinal fluid (CSF) and pressure on the neural structures.[1]

The approaches in posterior fossa surgery are used for accessing various tumors and vascular lesions including neuro-glial tumors, vestibular Schwannomas, inclusion tumors, meningiomas.[1,2] Post-operative cerebellar ptosis, CNF fistula and headache are the most important problems which impair quality of life of the patients besides neural complications following posterior fossa operations. Post-operative CSF fistula and headache are still the most important problems following these approaches.[2] Incidence of post-operative CSF fistula varies between 0% and 22%; and incidence of post-operative headache varies between 0% and 73% for recto-sigmoid approaches which is a posterior fossa intervention although varies depending on approach types.[2]

According to literature, the most protective factor for prevention of headache and CSF fistula is following the procedures carefully during surgical closure including meticulous dura repair and bone cranial reconstruction.[2] Dural closure using waterproof material or grafts (temporalis muscle tissue, artificial dura), closing bony openings using wax and wound follow up with lumbar drainage were reported as the most effective methods for prevention of CSF fistula.[2]

The most common causes of post-operative headache include CSF fistula, dural adhesion-related CSF circulation disorders and cerebellar ptosis (CP) although it may result from various causes. While various authors report different techniques in literature, posterior fossa reconstruction including both all-grafts and auto-grafts is the most recommended method to minimize post-operative headache and cerebellar ptosis.[2-6] These techniques have varying success. So no consensus is available about the best method for prevention of post-operative CSF fistula and headache.[2]

In this paper, we have planned to compare post-operative outcomes of the patients who underwent or who did not undergo posterior fossa surgery due to various reasons.

MATERIAL and METHOD

In the present study, 62 patients who underwent operation due to infra-tentorial intra-cranial mass lesion in Neuro-Surgery Clinic between 2014 and 2018 were evaluated retrospectively. The patients who did not come for regular post-operative controls were not included in the study. Local ethics committee approval was obtained prior to the study (IEAH: 28.09.2018:1446).

Patients were evaluated with regard to pre-operative diagnosis, age, gender, location of the pathology (parenchymal, extra-parenchymal), post-operative complications, presence of CSF fistula, alterations in headache.

The investigated parameters included post-treatment CSF fistula (incisional, otorrhea), type and duration of treatment, presence and radiologic measurement of post-operative cerebellar ptosis, incidence and severity of post-operative headache, duration of follow up. Post-operative headache severity (PHS) values on months 1,3 and 6 were recorded at the final follow up visit according to the scoring system defined by Catalano et al.7 Classification of headache was as follows: 0: no, 1: minor, not requiring medication, 2: requiring regular use of non-steriod anti-inflammatory drugs or acetaminophen, 3: requiring the use of high doses and effective analgesics, 4: severe, drug-resistant.

Statistical analyses

Statistical analyses were done using NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) program. Descriptive statistics (mean, standard deviation, median, first quartile, third quartile, frequency, percent, minimum, maximum) were used for assessment of data. Normality distribution of qualitative data was tested with Shapiro-Wilk test and plots. Mann-Whitney U test was used for inter-group comparisons of qualitative data which were not normally distributed. Friedman test was used for in-group comparisons of qualitative data which were not normally distributed and Bonferroni correction Wilcoxon signed-ranks test was used for assessment of paired comparisons. Quantitative data were compared using Fisher's exact test. A p level of <0.05 was accepted as statistically significant.

Surgical technique

All operations were performed in the same clinic. Decisions for indications and surgical strategies were made in the oncology council held weekly. Standard recto-sigmoid craniectomy was performed for cerebello-pontin angle pathologies, sub-occipital craniectomy was performed for cerebellar pathologies. Dura was closed using 4/0 vicryl and silk, auto-graft and allo-graft materials were used for a waterproof closure, when required. Open mastoid cells were closed using bone wax for obstructing any connections with middle ear. In the next stage of repair, it was ensured that there was no visible CSF leak from dural suture line and fibrin glue adhesive was applied on. Afterwards, cranioplasty was performed so as to completely close bone margins using a standard allograft cranioplasty material, poly-methyl-crylate (PMMA) (Figure 1). Skin and subcutaneous tissues were closed in accordance with anatomic layers using a standard method. Mastoid- suboccipital pressure wound dressing was done during post-operative 48 hours. Post-operative lumbar drainage was not used.

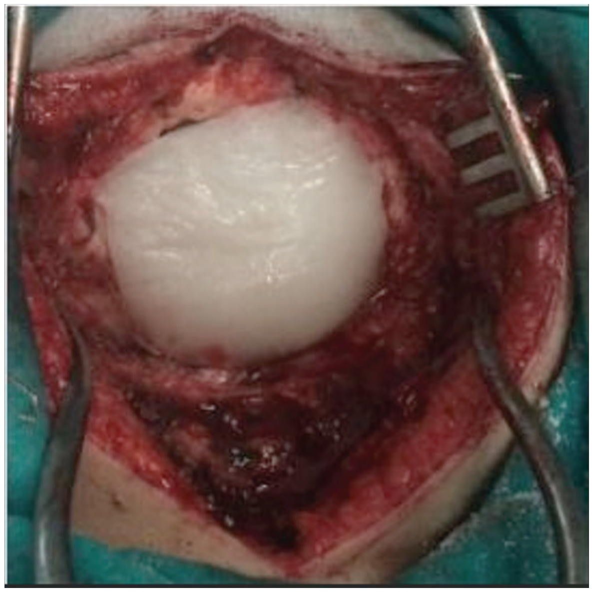

Figure 1. Cranioplasty so as to completely close bone margins using poly-methyl-methacrylate (PMMA), a per-operative allograft cranioplasty material

RESULTS

The study was conducted with 62 patients of whom 61.3% (n=38) were males and 38.72% (n=24) were females between 2014 and 2018. Mean age was 53.74 ±16.17 years (range 13-82). While 33.9% (n=21) of the patients underwent cranioplasty, 66.1% (n=41) did not undergo cranioplasty.

PHS on month one varied between 0 and 3 (mean 1.63 ±0.75), PHS on month 3 varied between 0 and 3 (mean 1.19±0.79) and PHS on month 6 varied between 0 and 2 (mean 0.97 ±0.75). Location of the pathology, number of operations, presence of CSF fistula, presence and size of cerebellar ptosis are summarized in Table 1.figure 2

Table 1. Distribution of patient characteristics((PHS: Postoperative headache severity)		
Cranioplasty	+	21 (33,9)
	-	41 (66,1)
PHS (1. Month)	Min-Max	0-3 (2)
	mean±Sd	1,63±0,75
PHS (3. Month)	Min-Max	0-3 (1)
	mean±Sd	1,19±0,79
PHS (6. Month)	Min-Max	0-2 (1)
	mean±Sd	0,97±0,75
Second Surgery	-	51 (82,2)
	+	11 (17,8)
CSF fistula	-	53 (85,5)
	+	9 (14,5)
Cerebellar ptosis	-	52 (83,9)
	+	10 (16,1)
Cerebellar ptosis(mm)	Min-Max	2-9 (4,5)
	mean±Sd	4,80±2,30

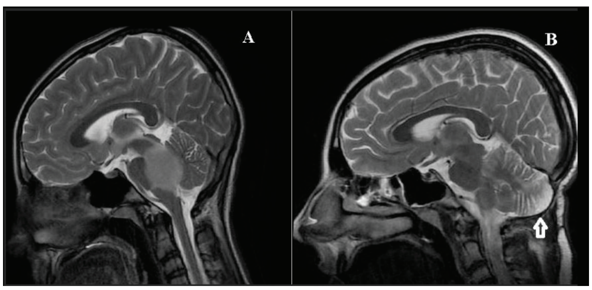

Figure 2. A demonstrative case with cerebellar ectopy. A. Pre-operative cranial sagittal MRI, B. Post-operative cranial sagittal MRI (white arrow: cerebellar ectopy)

Month 1,3 and 6 PHS was found statistically significantly lower among patients who underwent cranioplasty compared to the ones who did not undergo cranioplasty ($p=0,015$; $p<0,05$; $p=0,001$; $p<0,01$; $p=0,009$; $p<0,01$)(Table 2). A statistically significant difference was detected between the patients who underwent cranioplasty or not with regard to month 1,3,6 PHS scores ($p=0.001$; $p<0.01$). According to the paired comparisons done for detection of difference, mean 0.67 ±0.91 units of reduction in month 6 PHS scores compared to month 1 PHS scores was found to be statistically significant in patients who underwent cranioplasty ($p=0.049$, $p<0.05$), mean 0.66 ±0.85 units of reduction in month 6 PHS scores compared to month 1 PHS scores was found to be statistically significant in patients who did not undergo cranioplasty ($p=0.001$, $p<0.01$). A statistically significant difference was not found between the changes in month 1 and month 3 PHS scores with regard to undergoing cranioplasty ($p>0.05$) and a statistically significant difference was not found between the changes in month 1 and month 6 PHS scores with regard to undergoing cranioplasty ($p>0.05$) (Table 2) (Figure 3).

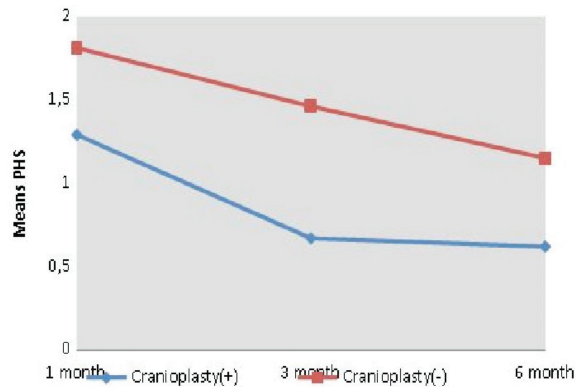

Figure 3. Distribution of PHS according to the groups with or without cranioplasty

A statistically significant difference was not found between presence of CSF fistula with regard to undergoing cranioplasty ($p>0.05$). Ratio of cerebellar ptosis was found statistically significantly lower in patients who underwent cranioplasty compared to the ones who did not undergo cranioplasty ($p=0.012$, $p<0.05$) (Table 3).

Table 3. Assessment of CSF fistula and cerebellar ectopy with regard to undergoing cranioplasty (CSF: Cerebro-spinal fluid)				
		Cranioplasty		
		Yes (n=21)	**No (n=41)**	**p value**
CSF fistula	-	17 (81,0)	36 (87,8)	$\chi2$:0,526
	+	4 (19,0)	5 (12,2)	**ᶜ0,472**
Cerebellar ptosis	-	21 (100,0)	31 (75,6)	$\chi2$:6,107
	+	0 (0,0)	10 (24,4)	**ᶜ0,012***
cFisher's Exact Test				

Table 2. Assessment of severity of post-operative headache severity with regard to undergoing cranioplasty (PHS: Post-operative headache severity). Assessment of CSF fistula and cerebellar ectopy with regard to undergoing cranioplasty (CSF: Cerebro-spinal fluid)

		Cranioplasty		
		Yes (n=21)	**No (n=41)**	**p value**
PHS (1. Month)	Min-Max	0-3 (1)	1-3 (2)	Z:-2,438
	mean±Sd	1,29±0,78	1,81±0,68	[a]**0,015***
PHS (3. Month)	Min-Max	0-2 (1)	0-3 (2)	Z:-3,849
	mean±Sd	0,67±0,58	1,46±0,74	[a]**0,001****
PHS (6. Month)	Min-Max	0-2 (1)	0-2 (1)	Z:-2,621
	mean±Sd	0,62±0,59	1,15±0,76	[a]**0,009****
	p value	χ2:16,270; **0,001****	χ2:20,959; **0,001****	
1 - 3 (Month)	Difference	-0,62±0,74	-0,34±0,85	Z:-0,915
	p	**0,076**	**0,160**	[a]**0,360**
1 – 6 (Month)	Difference	-0,67±0,91	-0,66±0,85	Z:-0,166
	p	**0,049***	**0,001****	[a]**0,868**
3 - 6 (Month)	Difference	-0,05±0,38	-0,32±0,79	Z:-1,687
	p	**1,000**	**0,328**	[a]**0,092**
CSF fistula	-	17 (81,0)	36 (87,8)	χ2:0,526
	+	4 (19,0)	5 (12,2)	[c]**0,472**
Cerebellar ptosis	-	21 (100,0)	31 (75,6)	χ2:6,107
	+	0 (0,0)	10 (24,4)	[c]**0,012***

[a]Mann Whitney U Test [b]Friedman Test *p<0,05 **p<0,01
[c]Fisher's Exact Test *p<0,05

A statistically significant difference was not found between month one PHS scores with regard to the location of the surgical pathology (parenchymal or extra-parenchymal) (p>0.05). Month 3 PHS scores were found statistically significantly lower in patients who had extra-pyramidal pathology compared to the ones with parenchymal pathology (p=0.003, p<0.01). Month 6 VAS scores were found statistically significantly lower in patients who had extra-pyramidal pathology compared to the ones with parenchymal pathology (p=0.022, p<0.05). A statistically significant difference was found between month 1,3,6 PHS scores in in-group comparisons of the patients with extra-parenchymal and parenchymal pathology (p=0.001, p<0.01) (Table 4, Figure 4).

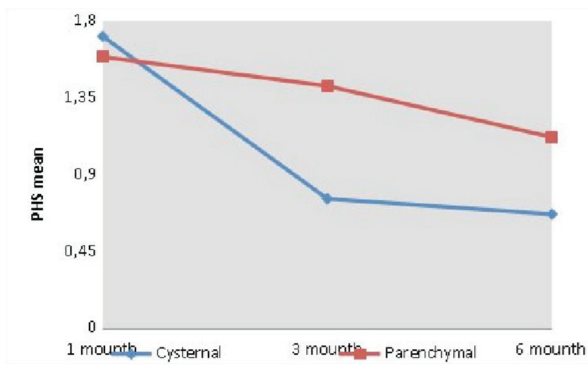

Figure 4. PHS distribution by cisternal-parenchymal

Table 4. Assessment of PHS scores with regard to the location of surgical pathology (parenchymal-extraparenchymal) (PHS: Post-operative headache severity)

		Extraparenchymal (n=21)	Parenchymal (n=41)	p value
PHS (1. Month)	Min-Max	0-3 (2)	0-3 (2)	Z:-0,864
	mean±Sd	1,71±0,85	1,59±0,71	**[a]0,388**
PHS (3. Month)	Min-Max	0-2 (1)	0-3 (1)	Z:-3,019
	mean±Sd	0,76±0,77	1,42±0,71	**[a]0,003****
PHS (6. Month)	Min-Max	0-2 (1)	0-2 (1)	Z:-2,285
	mean±Sd	0,67±0,73	1,12±0,71	**[a]0,022***
	p value	χ2:25,333; **0,001****	χ2:13,654; **0,001****	
1 - 3 (Month)	Difference	-0,95±0,74	-0,17±0,74	Z:-3,427
	p	**0,004****	**0,673**	**[a]0,001****
1 – 6 (Month)	Difference	-1,05±0,86	-0,46±0,81	Z:-2,361
	p	**0,001****	**0,028***	**[a]0,018***
3 - 6 (Month)	Difference	-0,10±0,70	-0,29±0,68	Z:-0,640
	p	**1,000**	**0,502**	**[a]0,522**

DISCUSSION

Operations performed for therapeutic purposes achieved the goal. It is difficult to associate all pre-operative complaints with etiology. Therefore the complaints on follow up were considered through excluding the symptoms related with etiologic factors and surgery as in many other studies.2 In this study, we have planned to compare the patients who underwent and who did not undergo posterior fossa craniotomy with regard to headache, CSF fistula, cerebellar ptosis. Skull reconstruction is important both for cosmetic purposes and also for protection from trauma.[8] The ideal reconstructive material should be easy to form, long standing, inexpensive, bio-compatible and resistant to infections.[9] While auto-grafts are more bio-compatible, allo-grafts reduce operative time and they have a higher potential to cause infections. Calvarial bone, subcutaneous fat tissue, muscle temporalis or nucal muscle and temporal fascia are among the widely used auto-grafts. Hydroxyapatite cement (HAC), poly methyl methacrylate (PMMA) bone cement, titanium web and poly-ethylene are the commonly used allo-grafts.2.[9] Poly methyl methacrylate (PMMA) bone cement was used in our patients. Post-operative CSF leakage may result from dural incisions, wound incisions, air cells transferred to middle ear and eustacian tube.[10] CSF otores may also develop following tympanic membrane penetration for intra-operative observation of cochlear nerve, tear of the connection between external canal and bony cartilage, although less frequent.[10] So a careful dural repair, closure of temporal bone air cells, meticulous closure of are required for prevention of post-operative CSF leakage.

It is important to close dura using sutures or allo-plastic dural patch in a waterproof way for prevention of post-operative dural leakages. Waterproof dural covers may be provided with various techniques including primary suture closure of temporal fascia graft, fibrin glue, suture closure in combination with Gelfoam.[2] Use of post-operative lumbar drainage does not seem necessary for prevention of CSF leakage even if this repair technique is applied carefully.[2] Lumbar drainage was not applied in post-operative early period in our serial.

The etiology of post-operative headache following posterior fossa craniectomy could not be fully understood however several hypotheses were proposed. Potential causes of post-operative headache include dural tension due to tight closure of dura, mastoid in bone region, displacement of the bone dust which arise during touring around the internal acustic canal toward subarachnoid space, attachment of subcutaneous tissues and muscles to dura and increased tension with head movements and neurogenic inflammation.[2.11.12] Schaller et al.[13] have reported a reduction in the incidence of new onset post-operative headache when they compared dura-plastic closure together with dura graft and direct dural closure. In our study, primary or secondary dural closure was not found to be associated with new onset post-operative headache. Spread of free bone dust to subarachnoid space may be prevented with a careful aspiration during bone drilling. Catalano et al. found the incidence of post-operative headache significantly low when they compared the incidence and severity of headache with regard to performing craniotomy.[7] Ling et al. have proposed that headache would be less with a careful aspiration and leaving the cisterns durable. We also consider that cranioplasty following craniectomy would prevent adhesions, in consistent with dural adhesion theory.[2.14] In our study, PHS was found statistically significant in patients who underwent cranioplasty ($p<0.001$).

CP was first defined by Williams in 1978.15 This severe complication has pulled little attention since its definition and several authors have published their experiences of CP management following sub-occipital craniectomies. Incidence of CP is not fully known and data from various authors are in a wide range. After the first definition of this condition, Duddy and Williams have reported CP in four out of seventeen patients who had MRIs before and after cranio-vertebral decompression.16 Downward ptosis of brainstem was observed in no patients who underwent posterior fossa reconstruction and in 7 out of 10 patients who underwent the operation in the study of Sahuquillo et al.17 Batzdorf et al.18 have reported CP in six patients who were managed with duraplasty and tonsil reduction, posterior cranial fossa decompression in their study conducted with 177 patients. In our series, CP was observed in no patients who underwent cranioplasty, varying degrees of statistically significant CP was observed in 10 out of 41 patients who did not undergo cranioplasty. Various rates in literature suggest that the magnitude of craniectomy seems to be an effective factor for CP. The present study reflects the outcomes of a single surgical team. Headaches resulting from cisternal evacuation and iatrogenic contamination were prevented through applying correct and standard techniques. We consider that this is associated with controlled surgical methods at cisternal level, leading to unnecessary cisternal impairment and prevention of transfer to the other cisterns through barriers. We consider that reconstruction of cranioplasty region is the most important factor for prevention of cerebellar ectopy.

CONCLUSIONS

The present preliminary study suggests that cranioplasty is useful for headache and cerebellar ectopy however insufficient for prevention of CSF fistula. It could be useful to evaluate headache, CSF fistula, cerebellar ptosis with further studies conducted with larger study populations including a control group.

Disclosures

Human subjects: All authors have confirmed that this study did not involve human participants or tissue.

Animal subjects

All authors have confirmed that this study did not involve animal subjects or tissue.

Conflicts of interest

In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work.

Financial relationships

All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Authors' Contributions

O.T.,M.K.,D.C., B.T., O.F.S.: conceptualization, data collection, and writing, statistical analysis, and writing; O.B., A.C..K., M.A.A.: conceptualization, data collection, supervision, and writing

Ethics committee approval

The Declaration of Helsinki was complied with while conducting the research, and approval was obtained from the Non-Interventional Clinical Research Ethics Committee of IEAH: 28.09.2018:1446

References

1. *Aslantürk Y, Yılmaz N, Ökten AI, Akbay FY, Basmacı M, Taşkın Y. Posterior Fossa Tümörlerinde Cerrahi Tedavi Sonuçları. Van Tıp Dergisi. 2006; 13 (1):4-8. https://vantipderg.org/jvi.aspx?pdir=vtd&plng=tur&un=VTD-71091*
2. *Ling PY, Zachary S, Rohit K, Jyung RW, Liu JK. Reconstruction after retrosigmoid approaches using autologous fat graft-assisted Medpor Titan cranioplasty: assessmentof postoperative cerebrospinal fluid leaks and headachesin 60 cases. Acta Neurochir. 2014; 156:1879–1888. DOI: 10.1007/s00701-014-2190-x*
3. *Castaño-Leon AM, Cepeda S, Paredes I. Symptomatic ptosis cerebelli after suboccipital craniectomy in a patient with severe brain trauma. Brain injury. 2017;31(10):1294-1297. DOI: 10.1080/02699052.2017.1309571*
4. *Holly LT, Batzdorf U. Management of cerebellar ptosis following craniovertebral decompression for Chiari I malformation. J Neurosurg. 2001; 94:21–6. DOI: 10.3171/jns.2001.94.1.0021*
5. *Heller JB, Lazareff J, Gabbay JS, Lam S, Kawamoto HK, Bradley JP. Posterior cranial fossa box expansion leads to resolution of symptomatic cerebellar ptosis following Chiari I malformation repair. J Craniofac Surg. 2007;18:274–80. DOI: 10.1097/scs.0b013e31802c05ab*
6. *Udani V, Holly LT, Chow D, Batzdorf . Posterior fossa recon- struction using titanium plate for the treatment of cerebellar ptosis after decompression for Chiari malformation. World Neurosurg. 2014; 81:836–41. DOI: 10.1016/j.wneu.2013.01.081*
7. *Catalano PJ, Jacobowitz O, Post KD. Prevention of headache after retrosigmoid removal of acoustic tumors. Am J Otol. 1996; 17:904–908. https://pubmed.ncbi.nlm.nih.gov/8915420*
8. *Moreira-Gonzalez A, Jackson IT, Miyawaki T, Barakat K, DiNick V. Clinical outcome in cranioplasty: critical review in long-term follow-up. J Cranio fac Surg. 2003; 14:144–153. DOI: 10.1097/00001665-200303000-00003*
9. *Aydin S, Kucukyuruk B, Abuzayed B, Aydin S, Sanus GZ. Cranioplasty. Review of materials and techniques. J Neurosci Rural Pract. 2011; 2:162–167. doi: 10.4103/0976-3147.83584*
10. *Elhammady MS, Telischi FF, Morcos JJ. Retrosigmoidap- proach: indications, techniques, and results. Otolaryngol Clin North Am. 2012; 45:375–397. DOI: 10.1016/j.otc.2012.02.001*
11. *Charalampakis S, Koutsimpelas D, Gouveris H, Mann W. Post-operative complications after removal of sporadic vestibular schwannoma via retrosigmoid-suboccipital approach: current diagnosis and management. Eur Arch Oto-Rhino-L. 2011, 268:653–660. DOI: 10.1007/s00405-010-1480-z*
12. *Wazen JJ, Sisti M, Lam SM. Cranioplasty in acoustic neuroma surgery. Laryngoscope. 2000; 110:1294–1297. DOI: 10.1097/00005537-200008000-00013*
13. *Schaller B, Baumann A. Headache after removal of vestibular schwannoma via the retrosigmoid approach: a long-term follow-up- study. Otolaryng Head Neck Surg. 2003; 128:387–395. DOI: 10.1067/mhn.2003.104*
14. *Soumekh B, Levine SC, Haines SJ, Wulf JA. Retrospective study of postcraniotomy headaches in suboccipital approach: diag- nosis and management. Am J Otol. 1996; 17:617–619. https://pubmed.ncbi.nlm.nih.gov/8841709/*
15. *Williams B. A critical appraisal of posterior fossa surgery for communicating syringomyelia. Brain. 1978; 101:223–50. DOI: 10.1093/brain/101.2.223*
16. *Duddy MJ, Williams B. Hindbrain migration after decompression for hindbrain hernia: a quantitative assessment using MRI. Br J Neurosurg. 1991; 5:141–52. DOI: 10.3109/02688699108998460*
17. *Sahuquillo J, Rubio E, Poca MA, Rovira A, Rodriguez-Baeza A, Cervera C. Posterior fossa reconstruction: a surgical tech- nique for the treatment of Chiari I malformation and Chiari I/ syringomyelia complex – preliminary results and magnetic resonance imaging quantitative assessment of hindbrain migration. Neurosurgery. 1994; 35:874–884. DOI: 10.1227/00006123-199411000-00011*
18. *Batzdorf U, McArthur DL, Bentson JR. Surgical treatment of Chiari malformation with and without syringomyelia: experi- ence with 177 adult patients. J Neurosurg. 2013; 118:232–242. DOI: 10.3171/2012.10.JNS12305*