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Surgical Technique

Endoscopic-assisted calvarial vault remodeling without postoperative helmets for treating infants with sagittal synostosis

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Abstract

Objective: Various endoscopically assisted minimally invasive surgical procedures have been described for the management of isolated nonsyndromic sagittal synostosis. All these techniques necessitate the use of postoperative helmets without immediate correction of the head shape. Here, we document the safety and sustainable acceptable outcomes of an endoscopic minimally invasive approach with full barrel staving without using a postoperative cranial helmet.

Methods: A single-institution cohort analysis was performed on five patients who underwent endoscopically assisted minimally invasive calvarial vault remodeling without using a postoperative helmet for isolated nonsyndromic sagittal synostosis between 2017 and 2022. Variables analyzed were age at the time of surgery, gender, Estimated Blood Loss (EBL), operative time, postoperative complications, and pre-and postoperative Cephalic Index (CI).

Results: Three male and two female infants were treated at our hospital in 2017–2022 with a mean follow-up of 32.6 months. At the time of the surgery, the mean age was ±3.5 months (range 10–58 months), the mean weight was 4.54 kg (standard deviation, SD ± 1.56), the mean EBL was 34.6 ml (range 20 ml – 54 ml) and mean surgical time from skin incision to dressing application was 120.7 min. The mean CI for all patients was 66.88 ± 4 (SD) preoperatively *vs.* 81.52 ± 2.38 (SD) postoperatively ($p < 0.001$ by paired Student's t - test). There were no deaths or intraoperative complications.

Conclusions: We present a novel endoscopically assisted minimally invasive procedure without using a postoperative helmet. This was a safe and efficacious procedure for isolated sagittal craniosynostosis, with improvements in CI at a mean follow-up of 32.6 months.

Introduction

Sagittal synostosis is the most common form of congenital craniosynostosis in infants [1]. The typical presentation is an abnormal head shape or increased intracranial pressure [2,3].

Many different surgical procedures have been reported to correct sagittal synostosis, ranging from the "gold standard" of bicoronal incision with a large strip craniectomy plus biparietal barrel staving to minimally invasive small suturectomy [4-6]. The open approach requires large scalp incisions and extensive bone work, resulting in significant blood loss to the patient. The minimally invasive approach has gained popularity over the last two decades after much evidence shows acceptable results with low morbidity [5,7-9]. However, the main disadvantage of this approach is the need for long-term use (up to 8 –12 months) of a molding helmet, which requires multiple adjustments [5]. Mutchnick and Maugans modified the procedure to avoid using a helmet, but it resulted in additional skin incisions without using endoscopy [9]. Here, we report on five patients who underwent endoscopically assisted strip craniectomy and full barrel staving without using a postoperative helmet for nonsyndromic sagittal synostosis. They had at least 6 months of follow-up.

Methods

Patient variables

A search on the King Fahad Medical City (KFMC) database

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for endoscopically assisted surgery for treating sagittal synostosis during 2017–2022 with a minimum of 6 months of follow-up revealed five cases. Data extracted from each patient's electronic chart included age at the time of surgery, gender, weight, Estimated Blood Loss (EBL), and preoperative and postoperative Cephalic Index (CI) at the last follow-up. The CI was determined by measurements from Computed Tomography (CT) images and calculated according to the following equation: CI = (cephalic width/cephalic length) × 100. The cephalic length was the distance between the most anterior and posterior outer points of the skull. The distance between the outer skull points at the widest region of the skull was taken as the cephalic width [10,11].

Surgical technique

At our institute, all endoscopies are conducted by the neurosurgery team alone, while open surgery involves a multidisciplinary team comprising neurosurgery and maxillofacial teams. All patients have a basic laboratory workup preoperatively, including complete blood counts and coagulation profiles. Preoperative CT is performed for all cases.

The first part of the surgery was performed as described by Jimenez, et al. [8]. Intraoperatively, after securing an endotracheal tube, two peripheral or central catheters and a Foley catheter were inserted into the patient in a prone position with slight head extension to expose the anterior fontanelle. Two transverse 2.5-cm incisions were marked posterior to the anterior fontanelle and just anterior to the lambdoid suture at the posterior fontanelle. The skin was opened with a 15 g knife followed by needle monopolar cautery through the galea aponeurotica, leaving the periosteum intact. At the posterior incision, a burr hole was made off the midline, and the bone opening was carried out using a Kerrison bone punch to cross the midline, making a square-shaped craniectomy centered at the posterior incision. Using Metzenbaum scissors, the plane between the galea and periosteum was dissected on each side of the square craniectomy to create a barrel-shaped staving A Penfield No. 1 instrument under direct endoscopic visualization was used to dissect the dura from the parietal bone from the incision down to the squamosal suture. Large Metzenbaum scissors were used to cut bones on each side. The same steps were repeated at the anterior incision. Triangular bone cuts were made just posterior to the coronal suture and anterior to the lambdoid suture. The bone edges were inspected using endoscopy, and hemostasis was maintained using bone wax, Bovie suction cautery, and hemostatic agents. Midline strip craniectomy of the sagittal suture was performed by dissecting the galea aponeurotica above the bone using Metzenbaum scissors. The dura was dissected by endoscopy using a Penfield No. 1 instrument. Emissary veins to the superior sagittal sinus were carefully identified and coagulated using bipolar cautery. Then, a planned 5-cm-wide craniectomy was performed by retracting the skin incision to the sides after dissecting the galea aponeurotica from the bone. The bone was cut using Metzenbaum scissors. The ovariectomized bone flap was divided into two halves to retrieve it through the skin incision. Then, barrel staving was performed using custom-made Alotaibi scissors (Figure 1). Four cuts of approximately 2 cm were made in each bone down to the squamosal suture: two on each side from the anterior incision and two from the posterior one. The bone strips were then greenstick fractured by pushing the bone from the inside using a Kerrison punch while the surgeon's hand was used to support the flap base at the level of the squamosal suture from the outside. The scalp incisions were then closed in two layers using interrupted 4-0 Vicryl sutures (Ethicon Inc., Bridgewater, NJ, USA) for the galea and a running 4-0 Vicryl suture for the skin; they were then covered with a sterile dressing. No patient has been prescribed a postoperative head molding helmet.

Results

Five patients (three male and two female) were treated at KFMC between 2017 and 2019 with a mean follow-up of 32.6 months (range 10–58 months). All patients were diagnosed and referred from other institutes. The diagnosis was confirmed clinically and radiologically using CT scans. None of the patients had papilledema upon funduscopic examination. At the time of surgery, their age was 3.5 ± 1.58 months (mean ± standard deviation, SD), mean weight was 4.54 ± 1.56 kg (mean ± SD), mean EBL was 34.6 ml (range 20 – 54 ml), and mean surgical time from skin incision to dressing application was 120.7 min. Three patients with preoperative low hemoglobin levels received mean blood transfusion volumes of 6 ml/kg (maximum 11.1 ml/kg) (Table 1). There were no deaths, dural tears, or sinus injuries. One patient had difficult intubation and an episode of desaturation and low blood pressure for 10 min, which was resolved before starting the procedure; unfortunately, 6 h after the operation he developed status epilepticus requiring intubation and sedation. Magnetic resonance imaging (MRI) showed posterior reversible encephalopathy syndrome. He recovered with a residual sustained area of diffusion restriction on MRI scans and was discharged home on antiepileptic medication.

Aesthetic outcomes

The CI was measured immediately preoperatively, and the

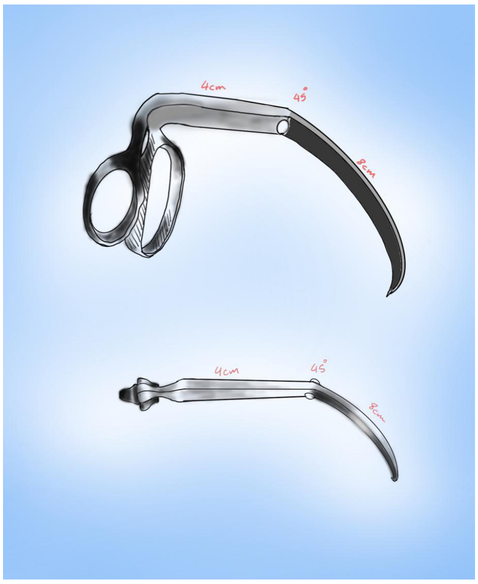

Figure 1: Right-angled Alotaibi's scissors show the shaft, tip length, and angles.

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postoperative analyses were obtained at each patient's last visit (a mean of 32.6 months after surgery). The mean CI for all patients was 66.88 ± 4 (SD) preoperatively *vs.* 81.52 ± 2.38 (SD) postoperatively ($p < 0.001$ by paired Student's t - test). Families of all the patients were satisfied with the head shape at the last follow-up. In four of the five patients, there was no bony defect; however, the last patient at 10 months follow-up had a small defect at the posterior parietal wedge craniectomy. None of the five patients required repeated surgery.

Discussion

The pathophysiology of craniosynostosis is not completely understood. Initially, studies focused on releasing fused sutures to re-establish normal anatomy and reduce intracranial pressure [12]. After gaining a better understanding of this congenital anomaly, it became evident that only a minority of affected patients will suffer from increased intracranial pressure, but most will suffer from poor cosmetic and esthetic issues with associated psychological impacts [13]. Since then, many procedures have been proposed, ranging from full cranial reconstruction to minimally invasive suturectomy. The first surgical case study was reported by Ingraham, et al. in 1948 [12]. Then, Massimi, et al. reported the first surgical attempts at curing sagittal synostosis [14]. After that, strip craniectomies became widely popular. However, in 1998, Jimenez and Barone reported on their experience with endoscopic strip craniectomies followed by the use of molding helmets [4]. Over the last two decades, this approach has become popular with various modifications ranging from adding endoscopically assisted barrel staving to microsurgery with and without helmet application [7,8,15,16].

Despite lacking robust evidence that the routine application of a postoperative helmet can achieve acceptable cosmetic results, most reported endoscopic approaches still apply it. However, it adds psychological and financial burdens to the patients and their families [17]. Mutchnick, et al. reported the first study of minimally invasive surgery to repair nonsyndromic sagittal synostosis without applying a helmet postoperatively [9]. They included 18 cases: the CI was 69 ± 7.7 (SD) preoperatively *vs.* 79 ± 4.4 (SD) postoperatively. They achieved an excellent cosmetic result by adding a third skin incision midway between the two conventional ones [9]. In addition, the bone was removed in a piecemeal fashion, which left bony irregularities in 30% of patients at a 10-month follow-up.

Our surgical technique in this study was based on a combination of using limited scalp incision and radial barrel staving without using a postoperative cranial helmet [8,9]. This technique allows proper biparietal expansion of the skull over time and produces no significant negative outcome for the patient. By adopting this technique we get both advantages of the open techniques; the barrel staving of partial bone and the endoscopic technique by having limited skin incisions. We combine direct visualization of the dura and subgaleal plane including emissary veins to the superior sagittal sinus using endoscopy [9].

Although our study had a small number of cases, our surgical and postoperative outcomes were consistent with those reported in the literature, with clear superiority in terms of cosmetic results and the CI [7,9,16,18,19]. We achieved significant improvements in the CI into the upper normocephalic range for the entire group and for all patients individually (Table 1). The superiority of the cosmetic results was expected because bone modeling was similar to that described in the open approach, namely resection of the sagittal suture with 2.5 cm on each side using biparietal barrel staving. Our cosmetic outcomes were sustainable because all our patients were followed for at least 10 months (mean 32.6), which is an acceptable period of follow-up to judge outcomes in the neurosurgical literature [20].

We have encountered no intra- or postoperative complications related to the surgical technique apart from one patient who had difficult intubation complicated by posterior reversible encephalopathy syndrome. Postoperative pain was minimal, so all patients were treated simply with paracetamol. Although we have shown excellent outcomes, we acknowledge that this study is too limited to make definitive conclusions about our modified surgical approach. Clearly, more studies with larger sample sizes are needed; nevertheless, we believe our outcomes are worth reporting to pediatric neurosurgeons dealing with craniosynostosis.

Conclusion

This study presents an endoscopically assisted correction of nonsyndromic sagittal synostosis using a full barrel staving procedure without a postoperative helmet. Despite the small sample size, our results demonstrate the safety and efficacy of this technique. This modified surgical approach can potentially reduce the financial, esthetic, and psychological impacts on patients and their families. Larger studies with bigger sample sizes investigating this technique are warranted.

Table 1: Demographic, clinical characteristics and outcome of 5 patients who underwent modified endoscopic, minimally invasive cranial vault remodeling.

cases	Age (Months)	Gender	Weight (KG)	EBL* (ML)	Transfusion Ml/kg	Operative time (Minutes)	Follow up (Months)	HGB Preop†	HGB Postop‡	Preop CI §	Postop CI
1	2	F	4.5	54	10.9	136.8	28	7.9	11.3	69.45	83.29
2	3	M	4.2	25	8	133.2	58	8	12.4	65.33	81.70
3	2.5	M	3.3	52	11.1	195	44	11.9	11.7	60.55	82.43
4	6	F	3.5	22	0	57.6	23	12.8	11.9	70.18	82.79
5	4	M	7.2	20	0	81	10	10.2	9.8	68.91	77.40

* Estimated blood loss; † preoperative; ‡ postoperative; § cranial index

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Ethics

This retrospective study was approved by the Institutional Review Board at KFMC (registration number H-01-R-012). This study was conducted in accordance with the Declaration of Helsinki, and the families of all the patients provided signed informed consent regarding this modified surgical approach. The modified surgical approach is the standard of care for open repair of sagittal craniosynostosis, which we were able to provide with an endoscopic approach.

Author contribution

Data collection, statistical analysis, and drafting of the manuscript were conducted completely by the primary author.

References

1. Kolar JC. An epidemiological study of nonsyndromal craniosynostoses. J Craniofac Surg. 2011 Jan;22(1):47-9. doi: 10.1097/SCS.0b013e3181f6c2fb. PMID: 21187784.
2. Fearon JA, Ditthakasem K, Herbert M. Reply: An Appraisal of the Cephalic Index in Sagittal Craniosynostosis, and the Unseen Third Dimension. Plast Reconstr Surg. 2018 Mar;141(3):459e-460e. doi: 10.1097/PRS.0000000000004154. PMID: 29485598.
3. Greensmith AL, Holmes AD, Lo P, Maxiner W, Heggie AA, Meara JG. Complete correction of severe scaphocephaly: the Melbourne method of total vault remodeling. Plast Reconstr Surg. 2008 Apr;121(4):1300-1310. doi: 10.1097/01.prs.0000304592.56498.d6. PMID: 18349649.
4. Jimenez DF, Barone CM. Endoscopic craniectomy for early surgical correction of sagittal craniosynostosis. J Neurosurg. 1998 Jan;88(1):77-81. doi: 10.3171/jns.1998.88.1.0077. PMID: 9420076.
5. Riordan CP, Zurakowski D, Meier PM, Alexopoulos G, Meara JG, Proctor MR, Goobie SM. Minimally Invasive Endoscopic Surgery for Infantile Craniosynostosis: A Longitudinal Cohort Study. J Pediatr. 2020 Jan;216:142-149.e2. doi: 10.1016/j.jpeds.2019.09.037. Epub 2019 Nov 1. PMID: 31685225.
6. Maugans TA, McComb JG, Levy ML. Surgical management of sagittal synostosis: a comparative analysis of strip craniectomy and calvarial vault remodeling. Pediatr Neurosurg. 1997 Sep;27(3):137-48. doi: 10.1159/000121241. PMID: 9548524.
7. Jimenez DF, Barone CM. Endoscopic techniques for craniosynostosis. Atlas Oral Maxillofac Surg Clin North Am. 2010 Sep;18(2):93-107. doi: 10.1016/j.cxom.2010.08.004. PMID: 21036312.
8. Jimenez DF, Barone CM, McGee ME, Cartwright CC, Baker CL. Endoscopy-assisted wide-vertex craniectomy, barrel stave osteotomies, and postoperative helmet molding therapy in the management of sagittal suture craniosynostosis. J Neurosurg. 2004 May;100(5 Suppl Pediatrics):407-17. doi: 10.3171/ped.2004.100.5.0407. PMID: 15287447.
9. Mutchnick IS, Maugans TA. Nonendoscopic, minimally invasive calvarial vault remodeling without postoperative helmeting for sagittal synostosis. J Neurosurg Pediatr. 2012 Mar;9(3):222-7. doi: 10.3171/2011.12.PEDS11306. PMID: 22380948.
10. Waitzman AA, Posnick JC, Armstrong DC, Pron GE. Craniofacial skeletal measurements based on computed tomography: Part II. Normal values and growth trends. Cleft Palate Craniofac J. 1992 Mar;29(2):118-28. doi: 10.1597/1545-1569_1992_029_0118_csmboc_2.3.co_2. PMID: 1571345.
11. Likus W, Bajor G, Gruszczyńska K, Baron J, Markowski J, Machnikowska-Sokołowska M, Milka D, Lepich T. Cephalic index in the first three years of life: study of children with normal brain development based on computed tomography. ScientificWorldJournal. 2014 Feb 4;2014:502836. doi: 10.1155/2014/502836. PMID: 24688395; PMCID: PMC3933399.
12. INGRAHAM FD, ALEXANDER E Jr, MATSON DD. Clinical studies in craniosynostosis analysis of 50 cases and description of a method of surgical treatment. Surgery. 1948 Sep;24(3):518-41. PMID: 18884128.
13. Singh VP, Moss TP. Psychological impact of visible differences in patients with congenital craniofacial anomalies. Prog Orthod. 2015;16:5. doi: 10.1186/s40510-015-0078-9. Epub 2015 Apr 18. PMID: 26061983; PMCID: PMC4402677.
14. Massimi L, Tamburrini G, Caldarelli M, Di Rocco C. Effectiveness of a limited invasive scalp approach in the correction of sagittal craniosynostosis. Childs Nerv Syst. 2007 Dec;23(12):1389-401. doi: 10.1007/s00381-007-0472-9. Epub 2007 Sep 18. PMID: 17876586.
15. Murad GJ, Clayman M, Seagle MB, White S, Perkins LA, Pincus DW. Endoscopic-assisted repair of craniosynostosis. Neurosurg Focus. 2005 Dec 15;19(6):E6. doi: 10.3171/foc.2005.19.6.7. PMID: 16398483.
16. Ridgway EB, Berry-Candelario J, Grondin RT, Rogers GF, Proctor MR. The management of sagittal synostosis using endoscopic suturectomy and postoperative helmet therapy. J Neurosurg Pediatr. 2011 Jun;7(6):620-6. doi: 10.3171/2011.3.PEDS10418. PMID: 21631199.
17. Breuninger J, Le Floch N. Postoperative nursing care of the endoscopic nonsyndromic craniosynostosis surgery patient. Plast Surg Nurs. 2008 Oct-Dec;28(4):183-5; quiz 186-7. doi: 10.1097/PSN.0b013e31818ea848. PMID: 19092583.
18. Cartwright CC, Jimenez DF, Barone CM, Baker L. Endoscopic strip craniectomy: a minimally invasive treatment for early correction of craniosynostosis. J Neurosci Nurs. 2003 Jun;35(3):130-8. doi: 10.1097/01376517-200306000-00002. PMID: 12830660.
19. Clayman MA, Murad GJ, Steele MH, Seagle MB, Pincus DW. History of craniosynostosis surgery and the evolution of minimally invasive endoscopic techniques: the University of Florida experience. Ann Plast Surg. 2007 Mar;58(3):285-7. doi: 10.1097/01.sap.0000250846.12958.05. PMID: 17471133.
20. Agrawal D, Steinbok P, Cochrane DD. Long-term anthropometric outcomes following surgery for isolated sagittal craniosynostosis. J Neurosurg. 2006 Nov;105(5 Suppl):357-60. doi: 10.3171/ped.2006.105.5.357. PMID: 17328257.

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