

# Endoscopic technique for sagittal synostosis

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## Abstract

**Purpose** This study aimed to present a 16-year experience of treating sagittal synostosis with endoscopic-assisted techniques and postoperative cranial orthotic therapy. In 1996, we introduced the use of endoscopes for the management of sagittal synostosis in four young infants. During the subsequent years, we have treated a total of 256 patients with great success and long-term follow-up. Presented herein are the techniques and results of such clinical experience.

**Methods** A total of 256 patients with sagittal synostosis have been treated between May 1996 and April 2012. There were 187 males and 69 females. Mean age at time of surgery was 3.9 months. A wide-vertex craniectomy with bilateral barrel stave osteotomies of the temporal and parietal bones using small scalp incisions and endoscopic viewing techniques was performed. Instruments have been developed to assist with the operation. All patients were placed in postoperative molding cranial orthosis.

**Results** Mean estimated blood loss was 27 cc. Mean transfusion rate was 7 %. Mean surgical time was 57 min. Mean length of stay was 1.1 days. Using cephalic index (CI) as an anthropometric measurement to judge head shape, our results were classified as excellent (CI>80), good (CI 80–70), or poor (CI<70). A total of 87 % were classified as excellent, 9 % as good, and 4 % as poor.

**Conclusions** Endoscopic-assisted management of sagittal synostosis is a safe, efficacious, and excellent option for treating this condition with long-lasting, superb results. It

is associated with minimal morbidity and complications and improved results over traditional procedures.

**Keywords** Craniosynostosis · Sagittal · Cranial suture · Endoscopy · Helmets

## Introduction

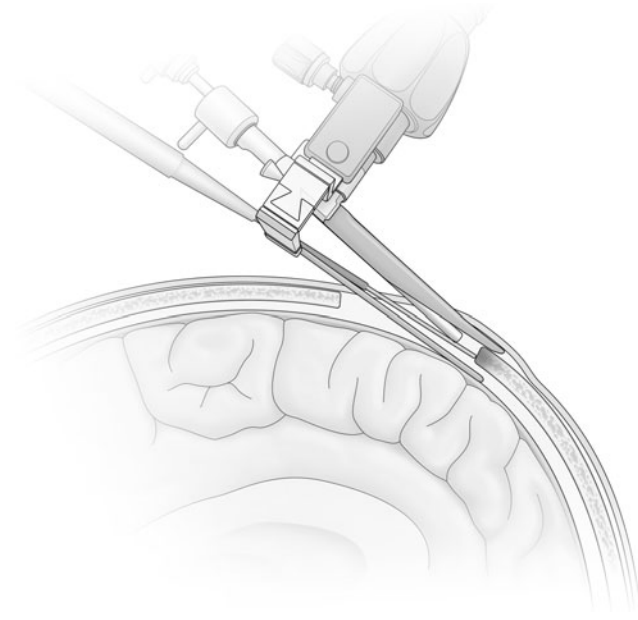
For decades, surgeons treating patients with craniosynostosis have struggled to find the operation that results in the best outcomes with the least number of complications. Procedures have spanned the spectrum from small linear craniectomies [11, 12] to extensive calvarial vault remodeling procedures [1–4, 8–10, 13, 14]. Results, however, have not been consistent, and oftentimes, multiple secondary operations may be necessary to correct unintended results. We reasoned that if a child with craniosynostosis is operated upon at a very early age, the subsequent rapid brain growth would allow for correction and normalization of the craniofacial skeleton. To assure full and long-lasting correction, we introduced the use of a custom-made cranial orthoses to be used in the postoperative period.

## Patient selection

The ideal candidate for this procedure is an infant under 3 months of age. The best results have been obtained in the youngest of patients. Because of how the procedure is designed and done, very young infants tolerate the operation well with minimal, if any, complications. The calvarial bone is very thin with a small diploic space with minimal blood loss. The extremely rapid brain growth, coupled with a thin calvarial, allows for rapid and full correction of the

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**Fig. 1** J&B Dural Retractor has two insulated blades designed to protect the dura and the galea while allowing direct endoscopic cauterization of the diploic space following the osteotomies. A suction–electrocautery unit is set at 60 W to rapidly achieve hemostasis under direct visualization

scaphocephalic skull. Patients between the ages of 3 and 6 months are still very good candidates and very good results are achieved, but surgery is somewhat more difficult to perform due to thicker bone and increased blood losses. Children between 6 and 9 months of age may still be considered candidates if their scaphocephaly and cranial

**Fig. 2** Endoscopic view of the subgaleal plane of dissection. The scalp is elevated with an insulated retractor blade (dark object at 12 o'clock) as the needle tip monopolar is used to cauterize the loose areolar tissue. The skull is seen on the bottom half of the image



deformity is minimal. Severe scaphocephalics in this age group or older than 9 months are not surgical candidates.

### Presurgical assessment, surgical armamentarium, and anesthesia

The diagnosis of sagittal synostosis can be made purely on a clinical basis but a CT scan of the head will be confirmatory. Once a general examination is done and any comorbidities are properly addressed, the patient may be taken for surgery. We do not routinely obtain extensive blood work and only get a heel stick hematocrit once the patient is under general anesthesia. There is no need for arterial, central venous lines or a Foley catheter. A single dose of antibiotics is given within an hour of the procedure. Standard rigid, 0° and 30°, 5-mm endoscopes (Karl Storz, Germany) are used for visualization. We have developed a set of instruments to aid with the procedure and these include special bone-cutting scissors and the J&B Dural Retractor (Karl Storz, Germany) which is used to aid in the cauterization of the diploic following the osteotomies (Fig. 1). The patient is placed in a sphinx position in a padded beanbag with the neck in extension.

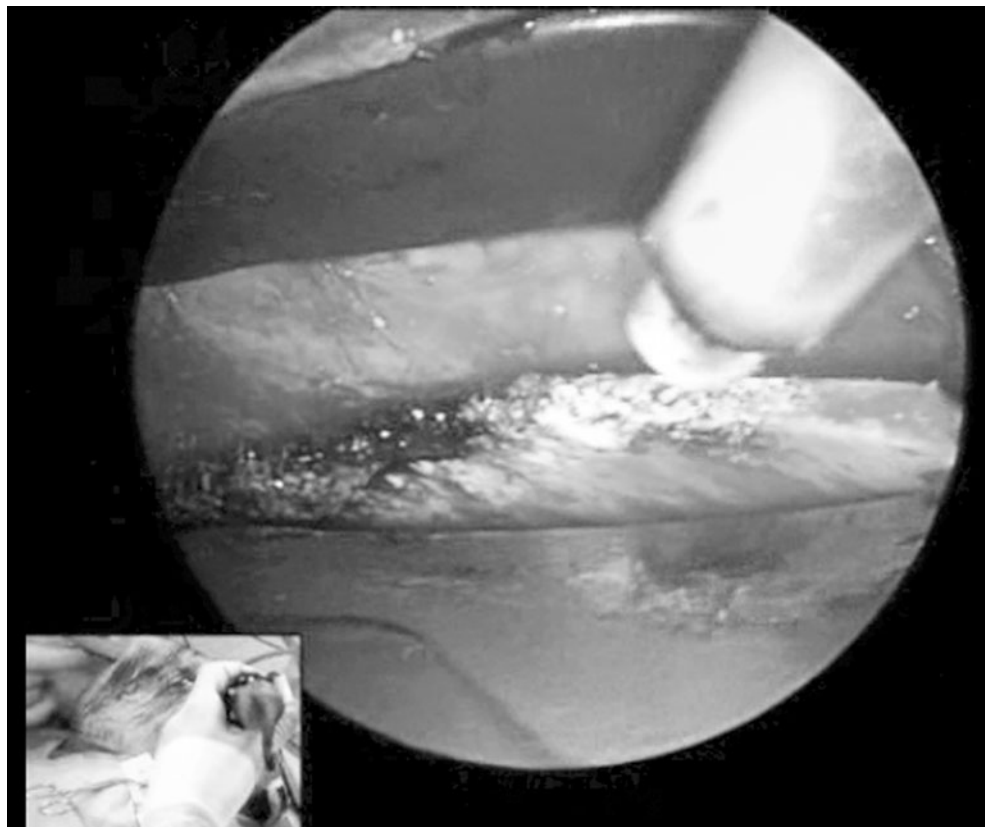
### Surgical technique

Once properly positioned, the head is prepped with a povidone-iodine solution. Our approach using endoscopes to treat sagittal synostosis has been previously well described

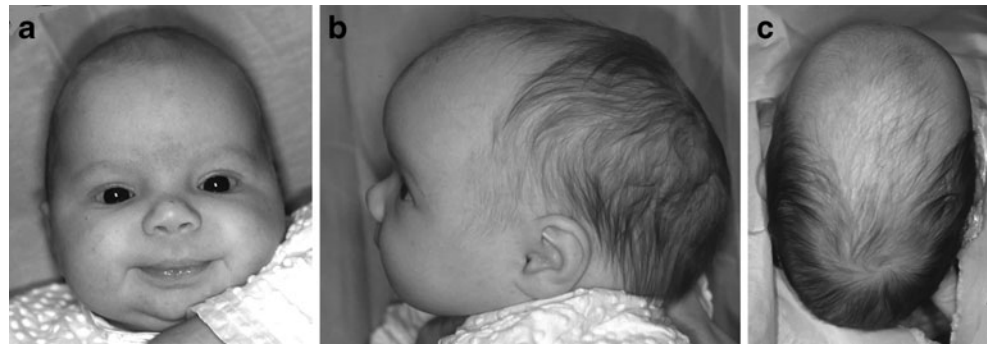
**Fig. 3** Endoscopic view showing the separation of the dura and sagittal sinus from the overlying stenosed suture. The dura is seen in the bottom half of the image while the groove of the stenosed sagittal sinus is seen in the upper half



**Fig. 4** Suction electrocautery is shown cauterizing the exposed bone of the paramedian osteotomy. The scalp and dura are being protected by the blades of the J&B Dural Retractor



**Fig. 5 a–c** Preoperative photographs of a 6-week-old female with classical sagittal craniosynostosis. The patient underwent endoscopic-assisted wide-vertex craniectomy with bilateral barrel stave osteotomies. Surgery time, 59 min; estimated blood loss, 20 cc; blood transfused, 0 cc; length of stay, 1 day

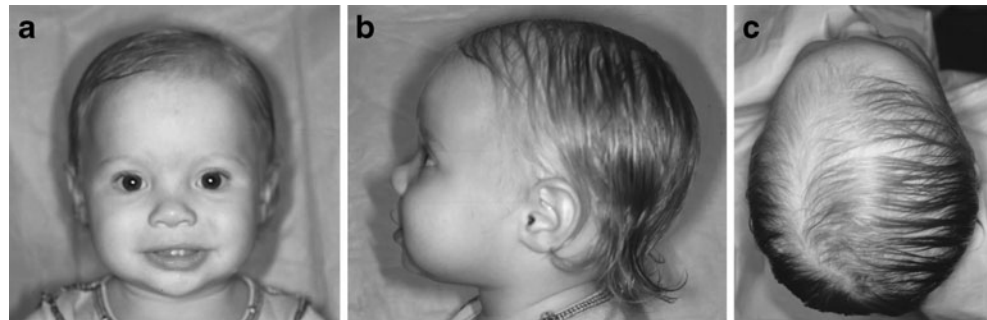


[5–7]. Although the procedure has changed little since the original introduction, a number of minor modifications have been added including new instrumentation to improve visualization and hemostasis. The patient is placed in the sphinx position, taking care to secure the endotracheal tube properly. After prepping with the povidone-iodine solution, two small incisions are made across the midline behind the anterior fontanelle and in front of the lambda. Subgaleal dissection is developed using scalp elevators and a 0° rigid endoscope (Karl Storz, Germany) and a needle tip monopolar electrocautery unit set at 15 W. This maneuver allows for bloodless

Frazier tip. The suction is used as a plane dissector and to keep the endoscopic visual field blood free (Fig. 3).

The endoscope and the suction tip are moved in tandem side to side and posteriorly until the lambda and lambdoid sutures are reached. Once the dura has been completely separated from the bone, lateral paramedian osteotomies are made with bone-cutting scissors (Karl Storz, Germany). The width of the osteotomy is inversely proportional to the baby's age; very young infants may have up to 5 or 6 cm of bone removed whilst an older child only may have 2 or 3 cm.

**Fig. 6 a–c** Postoperative views of the patient 13 months following surgery showing significant improvement

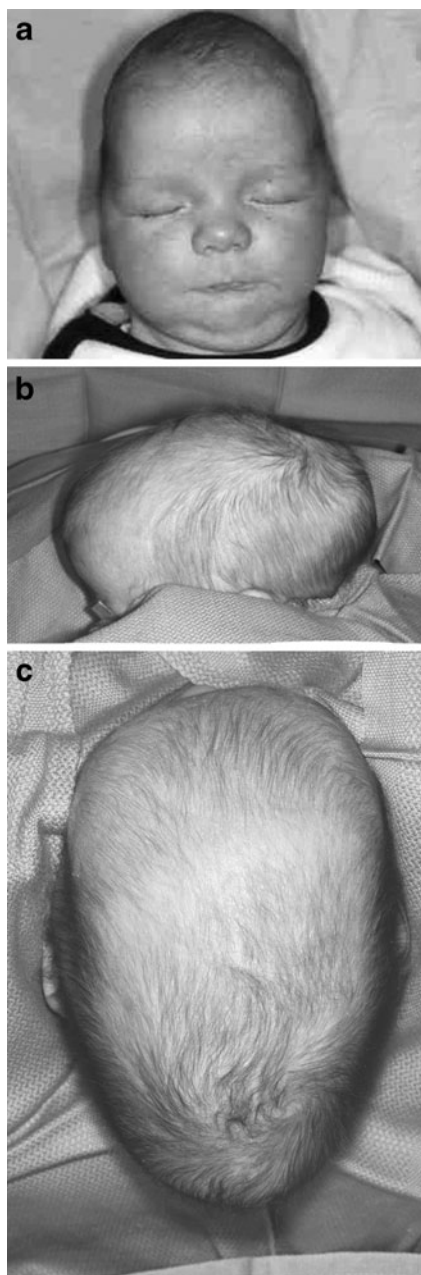


dissection while leaving the pericranium intact (Fig. 2). A single burr hole is placed on the side of each incision and osteotomies are made across the stenosed suture using Kerrison rongeurs. A wedge of bone is removed behind the anterior fontanelle and the anterior osteotomy. This will allow insertion of the rigid endoscope under the bone directed towards the lambda. The plane between the dura (sagittal sinus) and the overlying cranial bone is developed by advancing the endoscope alongside an insulated suction

Following removal of the midline strip of bone, wedge osteotomies are made bilaterally in front of lambdoid and behind the coronal sutures. This will provide a “clam shell” expansion of effect of the temporal bones to increase the cephalic index (CI). Bone hemostasis is extremely important to avoid postop complications. We developed a dural retractor–protector for this purpose (J&B Dural Retractor; Karl Storz, Germany). The insulated retractor blades protect the dura and elevate the scalp simultaneously while allowing

**Fig. 7 a–c** Two years after surgery, the patient has achieved and maintained full correction and normalization of the head shape





**Fig. 8** a–c Anterior–posterior, lateral, and top views of a 10-week-old male who was treated with the aforementioned endoscopic techniques for sagittal craniosynostosis

the surgeon to cauterize the bone under direct endoscopic visualization with a Bovie suction electrocautery unit (Valley Lab, PA) (Fig. 4). Final hemostasis can be obtained with Surgiflo® (Ethicon, Cincinnati, OH). The scalp is closed with galeal-absorbable sutures and the skin with Dermabond® (Ethicon, Cincinnati, OH). The patient is admitted for an overnight observation period and discharged on the morning following surgery. Within 5 days, a custom-made helmet (Orthomerica, Orlando, FL) which restricts growth in the anterior–posterior direction while allowing for bitemporal and biparietal expansion to occur.

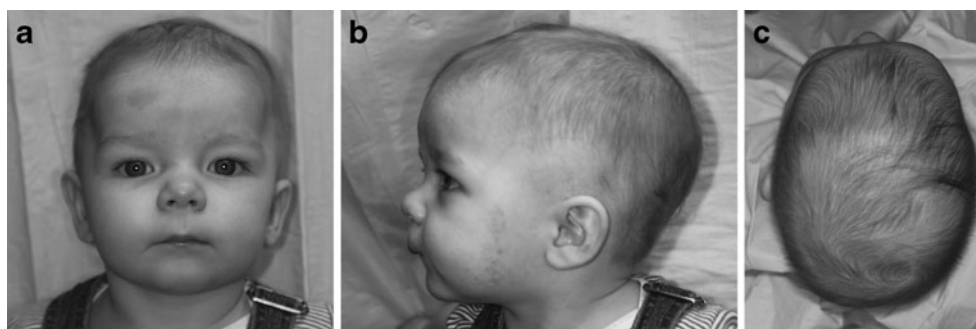
**Postoperative course**

The patient is taken to the surgical floor following the surgery and admitted for overnight observation. During the first 8 h, the patients tend to experience moderate pain which is managed with alternating oral acetaminophen and ibuprofen every 3 h with intravenous morphine every 1 hour as needed for breakthrough pain. Typically after 8 h, the patients settle down and require minimal pain medication. Most patients exhibit minimal to no facial or scalp swelling. Diet is advanced as tolerated. Nursing infants are allowed to nurse immediately after surgery. Almost all patients are discharged the morning following surgery. Two days later, they are scanned (Star Scanner, OrthoAmericas, Orlando, FL) for the manufacturing of the custom-made cranial orthosis, which is delivered on POD 5. A single postop day hematocrit is obtained prior to discharge from the hospital.

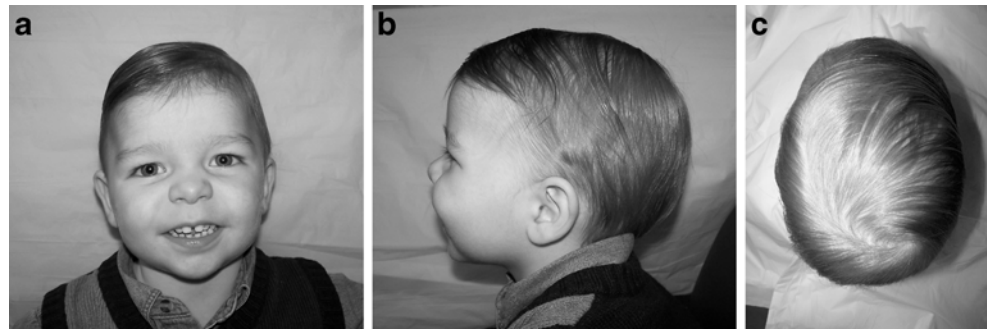
**Comparison with other techniques**

The ultimate goal of any procedure to correct craniosynostosis is to have full correction of the ensuing calvarial and facial deformities along with long-term and lasting correction. The aim should be that as the child reaches adolescence, it is impossible to tell that there ever was a deformity and that the child looks completely normal. Achieving such results have been difficult using traditional techniques. It is not uncommon for patients to require one or more corrective

**Fig. 9** a–c Ten months postoperative photographs show marked improvement of the patient's frontal bossing and occipital cupping



**Fig. 10 a–c** Two years after surgery, the patient continues to show persistent correction of all preoperative deformational changes



procedures to deal with abnormal results. “Bumps and lumps,” protruding hardware, asymmetric areas of bone growth, and areas of non-ossification are amongst the causes for the need of operation. Additionally, the dura mater has a genetically based tendency to resume a scaphocephalic head shape following release and treatment of sagittal synostosis. Our frustrations with subpar results led us to consider other surgical options in our efforts to obtain better results.

The introduction of endoscopes to perform minimally invasive techniques in very young patients seemed as a reasonable alternative in order to achieve better and longer lasting results. The use of cranial orthoses was introduced in order to counteract the genetically driven forces for relapse into scaphocephaly. We are pleased to report that long-term results validate our original hypothesis. Immediate correction begins to take place within 6 weeks of surgery and the helmets are used for up to 12 months in order to counteract natural forces for reversion to preop morphology and to maintain correction and normalized cephalic indices. Careful analysis of our anthropometric data, to include CI, shows that 18 months seem to be the turning point at which the patient will maintain his/her head shape indefinitely. The analysis of all graphs shows that CI stabilizes and is maintained during subsequent years as a flat line. Our longest follow-up of 15 years corroborates this finding. Extensive photographic documentation (Figs. 5, 6, 7, 8, 9, and 10) also corroborates our superior outcomes. None of the surgeries

needed to be converted to open operations. We have not experienced any postoperative hematomas or the need for surgery for their removal. Nor has there been a need for surgery to remove hardware as none is placed. Surgery is well tolerated given the fact that mean surgical time is under an hour and 93 % of the patients have not required blood transfusions.

The only limitations associated with our endoscopic approach revolve around patient's age at the time of surgery (Table 1). As previously mentioned, patients older than 9 months are not candidates and those with severe deformations between 6 and 9 months may also not be candidates. Surgery is well tolerated by the very young infants. As can be seen with our results which include low blood loss, low transfusion rates, short hospitalization times, and excellent long-lasting outcomes, endoscopic-assisted treatment of sagittal synostosis provides the treating surgeon and the patient with a safe and viable option for treating this condition.

**Table 1** Pros and cons

Pros	Cons
Excellent long-term result	Use of helmets for up to 1 year Limited use in patients older than 6 months
Minimal hospitalization	
Minimal blood loss	Long-term outcome dependent on helmet use and compliance
Very low transfusion rates	
Minimal swelling and pain	
Shorter operative times	
Well tolerated by young infants	
No need for expensive hardware	

## References

1. Amm CA, Denny AD (2005) Correction of sagittal synostosis using foreshortening and lateral expansion of the cranium activated by gravity: surgical technique and postoperative evolution. *Plast Reconstr Surg* 116:723–735
2. Boop FA, Chaddock WM, Shewmake K, Teo C (1996) Outcome analysis of 85 patients undergoing the pi procedure for correction of sagittal synostosis. *J Neurosurg* 85:50–55
3. Greene CS Jr, Winston KR (1988) Treatment of scaphocephaly with sagittal craniectomy and biparietal morcellation. *Neurosurgery* 23:196–202
4. Jane JA, Edgerton MT, Futrell JW, Park TS (1978) Immediate correction of sagittal synostosis. *J Neurosurg* 49:705–710
5. Jimenez DF, Barone CM (2000) Endoscopy-assisted wide-vertex craniectomy, “barrel-stave” osteotomies, and postoperative helmet molding therapy in the early management of sagittal suture craniosynostosis. *Neurosurg Focus* 9(3):e2, [www.neurosurgery.org/focus/sep00/9\\_3\\_nsf\\_toc.html](http://www.neurosurgery.org/focus/sep00/9_3_nsf_toc.html)
6. Jimenez DF, Barone CM, Cartwright C, Baker L (2002) Early management of craniosynostosis using endoscopic assisted strip craniectomies and cranial orthotic molding therapy. *Pediatrics* 110:97–104
7. Jimenez DF, Barone CM, McGee ME, Cartwright CC, Baker CL (2004) Endoscopy-assisted wide-vertex craniectomy, barrel stave osteotomies, and postoperative helmet molding therapy in the

- management of sagittal suture craniosynostosis. *J Neurosurg (Pediatrics)* 5) 100:407–417
8. Komuro Y, Ynai A, Hayashi A, Nakanishi H, Miyajima M, Arai H (2005) Cranial reshaping employing distraction and contraction in the treatment of sagittal synostosis. *Br J Plast Surg* 58:196–201
  9. Marchac D, Renier D, Broumand S (1994) Timing of treatment of craniosynostosis and faciocraniosynostosis: a 20 year experience. *Br J Plast Surg* 47:211–222
  10. Renier D, Lajeunie E, Arnaud E, Marchac D (2000) Management of craniosynostosis. *Childs Nerv Syst* 16:645–658
  11. Shillito J (1992) A plea for early operation for craniosynostosis. *Surg Neurol* 37:182–187
  12. Shillito J, Matson DD (1968) Craniosynostosis: a review of 519 surgical patients. *Pediatrics* 41:829
  13. Tullous MW, Henry MN, Wang PTH, Vollmer DG, Auber AE, Mancuso PA (2001) Multiple-revolution spiral osteotomy for cranial reconstruction. *J Neurosurg* 94:671–678
  14. Volmer DG, Jane JA, Park TS, Persing JA (1984) Variants of sagittal synostosis: strategies for surgical correction. *J of Neurosurg* 61:557–562