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COVER EDITORIAL

Single incision endoscope-assisted surgery for sagittal craniosynostosis

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Abstract
Objective The objective of this study is to present the novel technique and associated results of a single-incision endoscope-assisted procedure for the treatment of sagittal craniosynostosis.
Methods We retrospectively reviewed the charts of infants who underwent single-incision endoscope-assisted sagittal craniectomy for craniosynostosis at our institution. Demographic data collected included patient age, blood loss, operative time, pre- and post-operative hemoglobin, pre- and post-operative cephalic index (CI), and hospital length of stay.
Results Seven consecutive infants underwent surgery for sagittal craniosynostosis using a single-incision endoscopic technique. Average operative time was 87 (±10.5) minutes. Average blood loss was 32 (±13.5) cubic centimeters (cc). Post-operative hemoglobin was an average of 7.1 (±0.2) g/dL. No patients required a blood transfusion intra-operatively or in the post-operative setting. Dural tears were encountered in one patient. The average hospital length of stay was 1.4 (±1.1) days. Difference between pre- and post-operative CI was 8.4 % (±3.5; $p < 0.05$).
Conclusions We demonstrate the novel use of a single-incision technique for endoscope-assisted sagittal craniosynostosis correction that improves upon the classically described surgical procedure by decreasing invasiveness, while allowing for excellent clinical outcomes.

Keywords Endoscopic strip craniectomy · Minimally invasive · Sagittal craniosynostosis

Introduction

Craniosynostosis refers to the premature fusion of one or more of the cranial sutures which results in abnormal head shape. It has been described for centuries, although it was only recognized as a medical disorder during the late eighteenth century by von Sömmering [15]. Nonsyndromic sagittal synostosis, leading to the clinical phenomenon known as scaphocephaly, is the most common variant and occurs in approximately 5 in 10,000 live births [11, 15]. Endoscope-assisted suturectomy and post-operative helmet orthosis in newborns less than 3 months of age has become an increasingly widespread and favorable technique for surgical correction of single suture synostosis [2, 4, 5, 10–12, 16]. This minimally invasive approach, compared to more traditional surgical techniques for craniosynostosis, such as cranial vault remodeling, relies on rapid brain growth of the newborn in addition to helmet therapy to slowly correct asymmetric head shape while allowing for decreased blood loss, anesthesia time, and hospital length of stay [7, 13, 14]. As endoscopic synostosis surgery becomes more widespread, iterations of improvement have led to increased precision, efficiency, and safety [3, 6]. Traditionally, endoscope-assisted suturectomy for sagittal synostosis has involved two incisions, one at either end of the sagittal suture [12]. In an attempt to further minimize surgical invasiveness and blood loss, we have utilized a single-incision technique that allows for complete sagittal suturectomy. Here, we describe our early experiences with this technique.

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Materials and methods

Patient selection/data collection

All pediatric patients undergoing single-incision endoscope-assisted sagittal suturectomy for craniosynostosis were identified at our institution (Table 1). Information was retrospectively recorded, including patient age, blood loss, operating time, operative complications, pre- and post-operative hemoglobin, hospital length of stay, and pre- and post-operative cephalic index (CI). The study was conducted under approval of the institutional review board.

Surgical technique

The patient is taken to the operating room and intubated under general anesthesia. The baby is then positioned in a seal position on chest rolls, with all pressure points padded and the head fixed in a Pro Med DORO multipurpose skull clamp (Pro Med Instruments, Cape Coral, FL). A standard surgical prep is performed with povidone-iodine solution. A single, transverse incision about 3 cm in length is made crossing the midline about 1 cm posterior to the anterior fontanelle (Fig. 1). Electrocautery is used to dissect down to the bone. The posterior edge of the anterior fontanelle is then identified and the craniectomy is started using Kerrison rongeurs. This craniectomy is bridged across the midline and fashioned to be approximately 3 cm in width. Intermittent use of bone wax provides hemostasis during this stage. Cotton strips are then used to dissect the dura from the overlying bone and protect against inadvertent dural tears while an ultrasonic bone-cutting device (DePuy-Synthes piezoelectric system®, Palm Beach Gardens, FL, USA) is used to make lateral cuts parallel to the fused suture, a technique which has been previously described [6]. A 30°-angled rigid endoscope (Karl Storz, Germany) is then used to dissect and separate the overlying galea from the pericranium for the entire length of the sagittal suture. Bovie electrocautery is used to demarcate on the pericranium a 3-cm-wide section of bone for intended removal. The ultrasonic bone-cutting device is used to continue the craniectomy cuts posteriorly for the length of the suture (Fig. 2). Intervening bone is then removed with a Leksell rongeur. The craniectomy is extended until the lambdoid suture is visualized by identifying the point of posterior insertion of the dura, such that the entirety of the sagittal suture has been removed (Fig. 3). The dural surface is then inspected to ensure that no durotomies have occurred. Bipolar cautery is used throughout to provide dural hemostasis. All cotton is removed; the field is thoroughly irrigated and a strip of thrombin-soaked gelfoam is placed on top of the dural exposure. The galea is then sewn closed with interrupted, inverted Vicryl sutures, and the skin edges are approximated using absorbable Monocryl suture and skin glue. The patient is then extubated and taken to the recovery room. The patients begin helmeting about 1 week after surgery.

Statistical analysis

Summary data were presented as mean ± standard deviation as well as median values for age and weight. Analyses were performed using Stata (College Station, TX, USA). Values with $p < 0.05$ were considered statistically significant.

Results

Demographics

Seven consecutive patients (6 male, 1 female) underwent endoscope-assisted suturectomy for sagittal synostosis at our institution over the course of 9 months. The median patient age was 12.3 weeks. The median weight was 6.0 kg.

Table 1 Summary of seven patients who underwent single-incision endoscope-assisted sagittal craniosynostosis surgery

Patient number	Age (weeks)	Weight (kg)	Operative duration (min)	Blood loss (cc)	Preop CI	Postop CI
1	12.3	6.3	94	30	66	77
2	8.4	6.0	90	10	66	74
3	31.6	10.7	99	40	78	80
4	15.1	5.2	79	50	70	82
5	10.7	4.4	88	40	68	74
6	12.3	5.3	68	35	73	82
7	16.6	6.5	93	20	75	86
Mean (SD)	15.2 (7.7)	6.3 (2.1)	87.3 (10.5)	32.1 (13.5)	70.9 (4.6)	79.3 (4.5)
Median	12.3	6.0	–	–	–	–

SD standard deviation, *kg* kilogram, *min* minutes, *cc* cubic centimeters, *CI* cephalic index

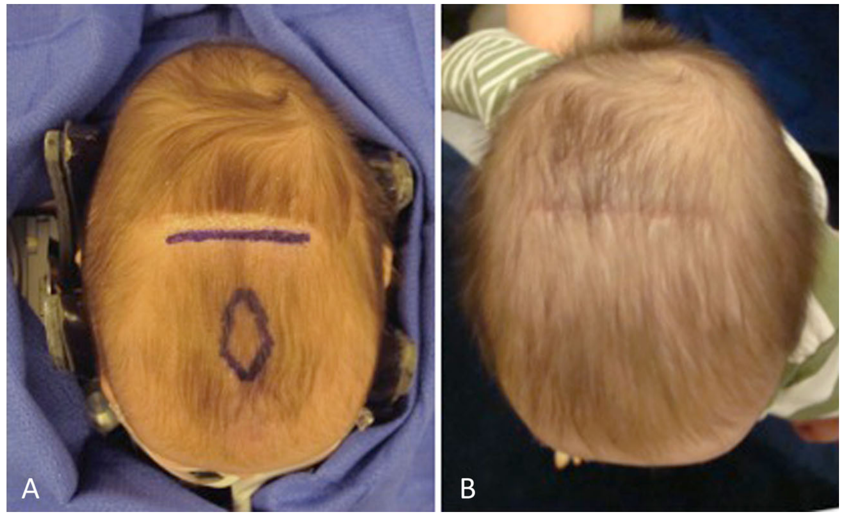

Fig. 1 Operative positioning, incision planning and post-operative outcome. **a** Pre-operative incision planning (*straight line*) in relation to the anterior fontanelle (*oval*) in a patient with sagittal craniosynostosis. **b** Three-month post-operative follow-up with improved head shape and good cosmetic result with a hidden scar

Outcomes

The average surgical time (±standard deviation) for all patients was 87 (±10.5) minutes. The average estimated blood loss per anesthesia records was 32 (±13.5) cubic centimeters (cc). Post-operative hemoglobin was measured in five out of eight patients and on average was 7.1 (±0.2) g/dL. There were no patients who required a blood transfusion intra-operatively or in the post-operative setting. In one patient, we encountered two small durotomies during surgery, which were repaired primarily followed by placement of an overlay synthetic dural substitute. There were no long-term complications encountered as a result. The average hospital length of stay was 1.4 (±1.1) days. The mean pre-operative cephalic index was 70.8 % (±4.6) and mean post-operative cephalic index, measured between 4 and 12 weeks after surgery, was 79.3 %

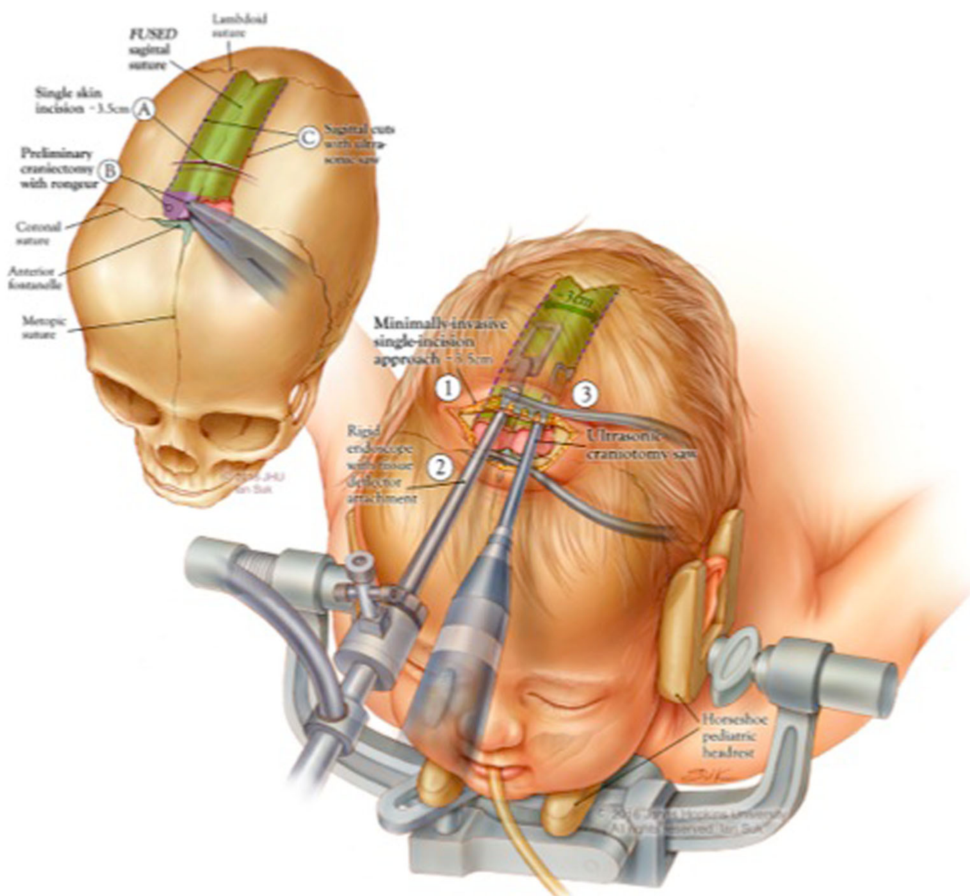

Fig. 2 Illustration depicting surgical technique for single-incision endoscope-assisted sagittal strip craniectomy. The *upper panel* depicts initial bony removal adjacent to the anterior fontanelle with a Leksell ronguer under direct visualization and the segment of intended bony removal (*green*) during the procedure. The *lower panel* depicts the intraoperative setup and positioning with the rigid endoscope providing subgaleal visualization with lateral cuts made parallel to the sagittal suture using the piezoelectric instrument. Illustration by Ian Suk, Johns Hopkins University

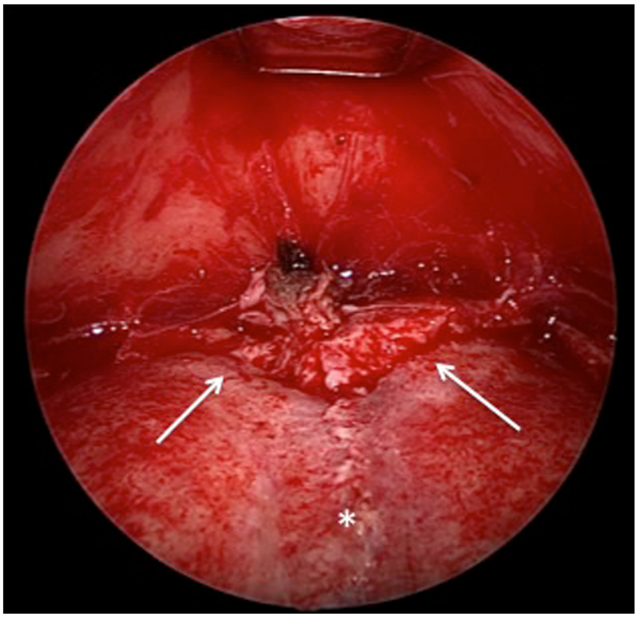

Fig. 3 An intraoperative endoscopic view after craniectomy through a single incision demonstrates the exposed lambdoid suture on either side of the midline. *White arrows* represent the triangular shape of the lambda as it is approached and the sagittal sinus (*asterisk*) marks the midline

(±4.5). The mean difference between pre and post-operative cephalic index was 8.4 % (±3.5; $p < 0.05$; 95 % CI 5.1–11.6).

Discussion

In this report, seven consecutive patients underwent endoscope-assisted suturectomy for sagittal synostosis with, to our knowledge, the first reported use of a single-incision technique. Average operating time was 87 min and mean blood loss was 32 cm^3. We encountered small durotomies in a single patient requiring primary repair. The average hospital length of stay was 1.4 days, and no patient required reoperation or suffered significant post-operative complications. No patient required a blood transfusion either intraoperatively or in the post-operative setting. Post-operatively, patients demonstrated significant correction in their CI at follow-up.

In the recent decades, advances in minimally invasive endoscope-assisted techniques for sagittal synostosis have made this a widespread, durable solution for infants less than 3 months of age [8, 11, 12]. The use of endoscope-assisted techniques with post-operative helmeting has been advantageous in the appropriately selected infants as it allows for a decrease in operative time and blood loss. In contrast, more traditional open techniques such as cranial vault remodeling are more invasive, have increased morbidity, and may require longer hospitalizations [1, 7, 9, 17].

Attempts to decrease invasiveness and refine surgical technique continue to advance the field of craniosynostosis surgery, leading to improved patient outcomes and even decreased cost of care [1, 6]. Classically described endoscope-assisted suturectomy for sagittal synostosis involves two incisions: one immediately posterior to the anterior fontanelle and a second immediately anterior to the lambda [11, 12]. In small infants with scaphocephaly, however, palpation of the lambdoid suture through the skin can be challenging, which can lead to imperfect incision placement and morbidity. Techniques have been described to attempt to mitigate this challenge with ultrasound guidance [3]. To circumvent this issue entirely, we employed a single-incision technique that allows the surgeon to approach the lambdoid suture internally and identify it directly. This obviates the need for a posterior incision and also a posteriorly placed burr hole, decreasing intraoperative blood loss and operating time. The use of a single incision has the obvious cosmetic advantage of one less scar and could potentially decrease post-operative pain and the likelihood of post-operative infection associated with irritation from the helmet.

We present the novel use of a single-incision technique for endoscope-assisted sagittal synostosis correction that we believe improves upon the classically described surgical procedure by increasing efficiency and decreasing invasiveness, while allowing for excellent clinical outcomes.

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Compliance with ethical standards The study was conducted under approval of the institutional review board.

Conflict of interest None.

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