A systematic review and meta-analysis of endoscopic versus open treatment of craniosynostosis. Part 1: the sagittal suture

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OBJECTIVE In this systematic review and meta-analysis the authors aimed to directly compare open surgical and endoscope-assisted techniques for the treatment of sagittal craniosynostosis, focusing on the outcomes of blood loss, transfusion rate, length of stay, operating time, complication rate, cost, and cosmetic outcome.

METHODS A literature search was performed in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Relevant articles were identified from 3 electronic databases (MEDLINE, EMBASE, and CENTRAL [Cochrane Central Register of Controlled Trials]) from their inception to August 2017. The quality of methodology and bias risk were assessed using the Effective Public Health Practice Project Quality Assessment Tool for Quantitative Studies. Effect estimates between groups were calculated as standardized mean differences with 95% CIs. Random and fixed effects models were used to estimate the overall effect.

RESULTS Of 316 screened records, 10 met the inclusion criteria, of which 3 were included in the meta-analysis. These studies reported on 303 patients treated endoscopically and 385 patients treated with open surgery. Endoscopic surgery was associated with lower estimated blood loss (p < 0.001), shorter length of stay (p < 0.001), and shorter operating time (p < 0.001). From the literature review of the 10 studies, transfusion rates for endoscopic procedures were consistently lower, with significant differences in 4 of 6 studies; the cost was lower, with differences ranging from $11,603 to $31,744 in 3 of 3 studies; and the cosmetic outcomes were equivocal (p > 0.05) in 3 of 3 studies. Finally, endoscopic techniques demonstrated complication rates similar to or lower than those of open surgery in 8 of 8 studies.

CONCLUSIONS Endoscopic procedures are associated with lower estimated blood loss, operating time, and days in hospital. Future long-term prospective registries may establish advantages with respect to complications and cost, with equivalent cosmetic outcomes. Larger studies evaluating patient- or parent-reported satisfaction and optimal timing of intervention as well as heterogeneity in outcomes are indicated.

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KEYWORDS craniosynostosis; scaphocephaly; endoscopic; sagittal suture; craniofacial

The incidence of craniosynostosis is estimated to be 3.0–6.4 per 10,000 live births; the majority of the cases are sporadic and a minority occur as part of a syndrome.6,24,29 There is a predominance of isolated sagittal synostosis or scaphocephaly, which accounts for more than half of all reported craniosynostosis cases and is estimated to occur at a rate of 1.0–2.5 in 5000 live births.10,24 Indications for surgical management of sagittal synostosis focus heavily on correcting dysmorphism (scaphocephaly) and the remote possibility of resolving elevated intracra-
It has been hypothesized that untreated sagittal craniosynostosis may lead to early speech and language problems and subsequent literacy issues, and to problems in related functions such as working memory, attention, and planning. Such adverse outcomes are the result of the elongation of the skull affecting the dorsolateral prefrontal cortex.

Infants with sagittal synostosis can be managed surgically with either traditional open surgery or the more contemporary technique of minimally invasive endoscope-assisted craniectomy followed by helmet therapy. As detailed in Bir et al., Lannelongue and Lane described the earliest treatment of sagittal craniosynostosis relying on suturectomies, and since then the treatment options for sagittal craniosynostosis greatly overshadow those for any other type of craniosynostosis. Open surgery historically includes a large range of techniques—from strip craniectomy, to the pi procedure, to occipital reduction—biparietal widening, which are each associated with longer operating time, longer hospital stay, and greater blood loss. Recognizing these suboptimal outcomes, Jimenez and colleagues proposed the novel technique of using endoscopy to perform sagittal suturectomy, followed by 4–6 months of helmet therapy to prevent anteroposterior growth. This technique is offered during the first 6 months of life, optimizing cosmetic and functional results.

Despite numerous adopters of the endoscopic technique, the clinical efficacy of the endoscopic method as it compares to traditional open techniques remains debated. Thus, in this systematic meta-analysis we aimed to directly compare open surgical and endoscope-assisted techniques for the treatment of sagittal craniosynostosis, focusing on the outcomes of blood loss, transfusion rate, length of hospital stay (LOS), operating time, complications, cost, and cosmetic outcome.

**Methods**

**Search Strategy**

This systematic review and meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.
and recommendations. A literature search was performed on MEDLINE, EMBASE, and CENTRAL (Cochrane Central Register of Controlled Trials) on August 17, 2017, by a librarian (M.A.). The database searches used keywords (individually and/or in combination) such as “craniosynostosis,” “endoscopic,” and “neuroendoscope” with the appropriate subject headings. The reference lists of retrieved articles were reviewed to identify additional relevant articles. An additional search was conducted prior to publication for inclusion of newly published studies.

### Study Selection

Retrieved studies were systematically assessed using inclusion and exclusion criteria by 2 reviewers (H.Y. and T.J.A.). Inclusion criteria were 1) diagnosis of sagittal craniosynostosis by a plastic surgeon or neurosurgeon; 2) at least 50% of the patient population had isolated sagittal craniosynostosis; 3) cohorts were divided into open surgery and endoscopically assisted surgery; and 4) follow-up outcomes were measured at 12 months or more. Exclusion criteria for the meta-analysis included 1) lack of quantitative comparison between open surgery and endoscopically assisted surgery; 2) nonhuman subjects; 3) inclusion of patients with syndromic craniosynostosis; and 4) editorials, abstracts, review articles, case reports, and dissertations. When duplicate studies were found, only the most complete reports were included for quantitative assessment. Studies from the same institution and possibly the same cohort of patients were only included if different outcome variables were reported.

### Data Extraction and Critical Appraisal

All data were extracted from article texts, tables, and figures. Each retrieved article was reviewed by 2 investigators independently (H.Y. and T.J.A.). Authors were contacted when there were missing or incomplete data. The quality of the methodology and the risk of bias across studies were assessed by 1 reviewer (H.Y.) using the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool for Quantitative Studies. Measured variables included selection bias, study design, confounders, blinding, data collection methods, and withdrawals and dropouts, as well as a global rating, and the tool rates each as “strong,” “moderate,” or “weak.”

### Statistical Analysis

Pooled effects between groups were calculated as standardized mean difference (SMD) with 95% CIs. Interstudy heterogeneity was not applicable because there were only 2 studies for each outcome. We used both random and fixed effects models to estimate the overall effect. A p value < 0.05 was set for statistical significance. Analysis was performed on “Comprehensive Meta-analysis” software (version 3.3, BIOSTAT).

### Results

#### Literature Search

The search strategy identified a total of 503 studies (Fig. 1). After removal of 187 duplicate studies, inclusion and exclusion criteria were applied to the titles of the remain-

### Table 1. Exclusion of eligible studies

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Excluded</th>
<th>Explanations &amp; Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbott et al., 2012</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Arts et al., 2018</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Bonfield et al., 2016</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Chan et al., 2013</td>
<td>Yes</td>
<td>Includes pts w/ syndromic craniosynostosis; pts w/ sagittal craniosynostosis represent 33% of cohort</td>
</tr>
<tr>
<td>Dvoracek et al., 2015</td>
<td>Yes</td>
<td>Overlapping pt population suspected</td>
</tr>
<tr>
<td>Esparza &amp; Hinojosa, 2008</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Farber et al., 2017</td>
<td>Yes</td>
<td>Pts w/ metopic craniosynostosis only</td>
</tr>
<tr>
<td>Garber et al., 2017</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Ghentstol et al., 2015</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Ghosh et al., 2014</td>
<td>Yes</td>
<td>Overlapping pt population suspected</td>
</tr>
<tr>
<td>Han et al., 2016</td>
<td>No</td>
<td>Overlapping pt population confirmed; included for largest cohort size</td>
</tr>
<tr>
<td>Hashim et al., 2014</td>
<td>Yes</td>
<td>Analysis of neuropsychological outcomes only</td>
</tr>
<tr>
<td>Keshavarzi et al., 2009</td>
<td>Yes</td>
<td>Pts w/ metopic craniosynostosis only</td>
</tr>
<tr>
<td>Keshavarzi et al., 2010</td>
<td>Yes</td>
<td>Pts w/ sagittal craniosynostosis represent 45% of cohort</td>
</tr>
<tr>
<td>Kohan et al., 2008</td>
<td>Yes</td>
<td>Case studies of twin pts</td>
</tr>
<tr>
<td>Le et al., 2014</td>
<td>Yes</td>
<td>Overlapping pt population suspected</td>
</tr>
<tr>
<td>MacKinnon et al., 2009</td>
<td>Yes</td>
<td>Pts w/ unilat coronal craniosynostosis only; overlapping pt population &amp; data suspected</td>
</tr>
<tr>
<td>MacKinnon et al., 2013</td>
<td>Yes</td>
<td>Pts w/ unilat coronal craniosynostosis only; overlapping pt population &amp; data suspected</td>
</tr>
<tr>
<td>Nguyen et al., 2015</td>
<td>Yes</td>
<td>Pts w/ metopic craniosynostosis only</td>
</tr>
<tr>
<td>Nowaková et al., 2015</td>
<td>Yes</td>
<td>Translated from Czech; nonquantitative data</td>
</tr>
<tr>
<td>Rogers et al., 2015</td>
<td>Yes</td>
<td>Measured outcome is hand preference</td>
</tr>
<tr>
<td>Shah et al., 2011</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Siu et al., 2014</td>
<td>Yes</td>
<td>Case studies of 2 pts w/ unilat coronal craniosynostosis &amp; Down syndrome</td>
</tr>
<tr>
<td>Tan et al., 2013</td>
<td>Yes</td>
<td>Pts w/ unilat coronal craniosynostosis only</td>
</tr>
<tr>
<td>Thompson et al., 2018</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Vogel et al., 2014</td>
<td>No</td>
<td>Overlapping pt population confirmed w/ authors; included for unique data</td>
</tr>
<tr>
<td>Yarbrough et al., 2014</td>
<td>Yes</td>
<td>Case series of 5 pts w/ mixed suture types</td>
</tr>
<tr>
<td>Zubovic et al., 2015</td>
<td>Yes</td>
<td>Pts w/ unilat lambdoid craniosynostosis only</td>
</tr>
</tbody>
</table>

NA = not applicable; pts = patients.
Endoscope-assisted craniosynostosis surgery has a significantly shorter LOS compared to open craniotomies, based on 2 studies (SMD −1.66 days, 95% CI −1.86 to −1.46; p < 0.001) (Fig. 2B). Thompson et al.\textsuperscript{44} conducted a multicenter retrospective study analyzing 933 propensity score–matched children and reported a median LOS of 2 and 4 days for endoscopic and open surgery, respectively. Abbott et al.\textsuperscript{1} also described a shorter LOS for endoscopic surgery compared to open surgery, with medians of 1 day and 3 days, respectively. A Spanish study\textsuperscript{8} measured mean time of hospitalization as a consequence of postoperative complications and found that endoscopic osteotomies (11.2 days) resulted in shorter stays compared to open sagittal suturectomy, open sagittal suturectomy with frontal dismantling, and total cranial vault remodeling (12.4, 11.5, and 16.2 days, respectively).

**Operating Times**

Endoscope-assisted craniosynostosis surgery had a significantly lower operating time compared to open craniotomies, based on 2 studies (SMD −1.68 days, 95% CI −1.87 to −1.48; p < 0.001) (Fig. 2C). Likewise, Thompson et al.\textsuperscript{44} and Abbott et al.\textsuperscript{1} reported medians of 1.16 and 2 hours for endoscopic procedures and 2.16 and 6 hours for open procedures.

**Transfusions**

Six studies\textsuperscript{1,2,4,11,16,44} reported a lower need for intraoperative and postoperative transfusions for patients undergoing endoscopic procedures compared to open cranial surgery. Endoscopic procedures showed a transfusion rate ranging from 0%\textsuperscript{1} to 26%\textsuperscript{2,44} of patients and open procedures ranged from 16%\textsuperscript{44} to 100%\textsuperscript{1} (Table 4).

**Complications**

Eight studies\textsuperscript{1,2,4,8,11,16,39,44} reported on complications of open and endoscopic treatment of sagittal synostosis (Table 5). These studies all used different metrics to analyze rates of complications at various time points, including during the operation, during the hospital stay, and at various lengths of follow-up. Although statistical analysis was not reported, 6 studies reported equal or lower rates of complications.
complications for endoscopically treated patients. Han et al. observed complication rates at 4 time points and found no statistical difference between endoscopic and open surgery (range, p = 0.140 to p = 0.921). Most notably, 3 studies reported a lower reoperation rate for endoscopic techniques compared to open surgery.

Cosmetic Outcomes

Two studies from different patient populations compared postoperative cranial index, both of which showed no statistical difference. Abbott et al. reported a postoperative cranial index of 0.77 and 0.75 for endoscopic and open procedures, respectively, with no significant difference. Likewise, Shah et al. also demonstrated a cranial index of 0.76 and 0.77 (p = 0.346) for endoscopic and open procedures. Finally, Ghenbot et al. looked at cranial vault volume, showing no significant difference for the endoscopic and open cohorts (p = 0.31), although the patients in this cohort were probably also all analyzed by Shah et al.

Cost of Treatment

Three studies looked at the cost of craniosynostosis treatment. Abbott et al. and Vogel et al. analyzed the total cost of treating craniosynostosis, including the medical cost of hospital and physician fees, orthotic cost of helmet fittings, and indirect patient costs of travel and lost work days. The median (range) of the endoscopic and open surgery cost was $23,377 ($20,987–$24,977) and $55,121 ($44,690–$86,313), respectively, and the reported mean cost of endoscopic and open surgery was $37,356 and $56,990, respectively. Looking solely at medical costs, endoscopic procedures again were found to be cheaper ($21,203) than open procedures ($32,806).

Discussion

In this meta-analysis and literature review, we found that surgical treatment of sagittal synostosis by endoscope-assisted surgery was associated with shorter operating room times, shorter LOS, reduced rates of transfusion, and similar cosmetic results at last follow-up (as measured by cranial index), compared with open surgery. Important differences highlighted include the age at time of surgery, which was consistently younger for children undergoing endoscopic repair. The study by Esparza and Hinojosa shows the differences between North American and European treatment; despite the difficulty in performing a direct comparison, the inclusion of this study highlights how different healthcare systems will have an impact on treatment options. Although a myriad of techniques for both open and endoscopic repair have been reported, rendering comparisons difficult, our meta-analysis provides the most comprehensive synthesis of the available literature pertaining to the surgical treatment of sagittal synostosis with open and endoscopic methods.

Perioperative Outcomes

Endoscopic treatment of craniosynostosis has significantly less estimated blood loss than open surgery. Consequently, the rate of transfusion has been found to be
Bonfield et al. summarized 37 published studies that have investigated blood transfusion rates in craniofacial procedures, although they did not report any studies that directly compared endoscopic to open procedures. Although blood transfusion safety has improved over time, infants have a greater incidence of adverse outcomes than adults (37 vs 13 cases per 100,000 red blood cells transfused, respectively). This is most often due to complications such as transfusion-related acute lung injury (TRALI) and transfusion-related circulatory overload (TACO). Therefore, it is important to minimize the need for transfusion when performing surgery on infants. In their multicenter study of 31 institutions, Thompson et al. regretted the documented inaccuracies of blood loss estimates and sought alternatives to study this important metric.

The length of operating time and LOS for endoscopically treated patients was significantly shorter with endoscopy-assisted correction of sagittal synostosis, as seen in 5 studies. Although the American studies show LOS means ranging from 1 to 4 days, Esparza and Hinojosa admit that their mean time of 11.9 days is unacceptable; their longer hospital stays seen in sagittal expansive osteotomies (12.4 days) and sagittal holocranial dismantling (16.2 days) are related to postoperative complications. This further suggests that the less invasive endoscopic techniques may reduce operating time and hospital stay.

### TABLE 4. Transfusion rates between endoscopic and open treatments of sagittal craniosynostosis

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Treatment</th>
<th>Transfusion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbott et al., 2012</td>
<td>pRBC</td>
<td>0* 100*</td>
</tr>
<tr>
<td>Arts et al., 2018</td>
<td>pRBC</td>
<td>26 81</td>
</tr>
<tr>
<td>Bonfield et al., 2016</td>
<td>pRBC</td>
<td>7.1 17.0</td>
</tr>
<tr>
<td>Garber et al., 2017</td>
<td>Endo vs CVR</td>
<td>13* 83*</td>
</tr>
<tr>
<td>Han et al., 2016</td>
<td>Intraop pRBC</td>
<td>5.0* 96.1*</td>
</tr>
<tr>
<td>Thompson et al., 2018</td>
<td>RBC blood products</td>
<td>26* 81*</td>
</tr>
</tbody>
</table>

CVR = total cranial vault reconstruction; FFP = fresh frozen plasma; pRBC = packed red blood cells; SSC = open sagittal strip craniectomy.

* p < 0.05.
Complications

Eight studies\textsuperscript{1,2,4,8,11,16,39,44} seem to support an equivalent or decreased complication rate for endoscopically assisted surgeries compared to open surgery. Future research should document the most common or most severe complications at each stage of treatment to provide the opportunity for analysis across studies. None of the included studies reported a higher incidence of injury to the sagittal sinus due to endoscopic surgery compared to open surgery. Because it is a novel technique, endoscopic surgery encompasses a large variability in outcomes and complications between different surgeons and procedures.

Cosmetic Outcomes

It has not yet been clearly defined how to best measure the postoperative aesthetic improvements after craniosynostosis surgery. The average cranial index (i.e., maximal cranial width/length) of children younger than 3 years of age was measured at 0.815.\textsuperscript{31} In children with sagittal synostosis, the cranial index is as low as 0.65.\textsuperscript{14} Our study shows that both endoscopic and open corrections, with cranial index ranging from 0.75 to 0.77, are able to achieve comparable postoperative results.\textsuperscript{139} Ghenbot et al.\textsuperscript{12} analyzed cranial vault volume in addition to cranial index and found no difference in cranial vault volume, assuaging the concern that molding helmet therapy would lead to volume restriction. Future studies evaluating these techniques must take into account variability in outcomes among children as well as other measures of cosmesis, including parent or patient impression and satisfaction.

Cost of Treatment

In 3 different populations,\textsuperscript{11,45} the cost of endoscopic treatment with helmet therapy follow-up was found to be lower than the cost of open surgery, with differences ranging from $11,603 to $31,744. The difference is mostly attributable to the more invasive and extensive nature of open cranial surgery, often requiring ICU observation, transfusions, or a higher rate of revision. The costs of helmets were reported in all included studies; however, there are several indirect costs and also additional time needed for postoperative helmet servicing that have not been measured in the published literature. Furthermore, there may be unaccounted obstacles and unknown patient or parent impressions of helmet usage that have not been studied. The long-term efficacy and costs require ongoing research.

\begin{table}
\centering
\caption{Complications in patients with sagittal craniosynostosis undergoing endoscopic and open surgery}
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline
Authors & Year & No. of Pts & Complication & Endoscopic & Open & \\
\hline
Abbott et al., 2012 & 10 & 10 & Postop emergency visits & 0.0 & 0 & 30.0 & 3 \\
\hline
Arts et al., 2018 & 63 & 30 & Intraop complications & 1.6 & 1 & 3.3 & 1 \\
\hline
 & & & Postop complications & 4.7 & 3 & 3.3 & 1 \\
\hline
 & & & Reoperation & 1.6 & 1 & 3.3 & 1 \\
\hline
Bonfield et al., 2016 & 28 & 71 & Cardiovascular or wound healing & 0.0 & 0 & 0.0 & 0 \\
\hline
Esparza & Hinojosa, 2008 & 39 & 116 & Reoperation & 2.6 & 1 & 9.5 & 11 \\
\hline
 & & & Wound infection & 2.6 & 1 & 0.0 & 0 \\
\hline
 & & & Subgaleal hematoma & 0.0 & 0 & 5.2 & 6 \\
\hline
 & & & Infected hematoma & 0.0 & 0 & 3.4 & 4 \\
\hline
 & & & Dural tear & 0.0 & 0 & 0.8 & 1 \\
\hline
 & & & Craniolacunae & 0.0 & 0 & 2.6 & 3 \\
\hline
 & & & Plate scarring & 0.0 & 0 & 1.7 & 2 \\
\hline
 & & & Postop hyperthermia & 10.3 & 4 & 15.5 & 18 \\
\hline
 & & & Infection\textsuperscript{*} & 1.7 & 4 & 2.3 & 16 \\
\hline
Garber et al., 2017 & 100 & 200 & Revision surgery & 1.0 & 1 & 7.0 & 14 \\
\hline
Han et al., 2016\textsuperscript{†} & 140 & 155 & Surgical complications & 2.1 & 3 & 1.3 & 2 \\
\hline
 & & & Intraop durotomies & 3.6 & 5 & 7.8 & 12 \\
\hline
 & & & Postop complications & 3.6 & 5 & 4.5 & 7 \\
\hline
 & & & Readmit <30 days & 1.4 & 2 & 1.3 & 2 \\
\hline
Shah et al., 2011\textsuperscript{†} & 47 & 42 & Wound revision & 2.1 & 1 & 2.4 & 1 \\
\hline
Thompson et al., 2018 & 311 & 622 & Hypotension requiring pressors & 3 & 8 & 4 & 23 \\
\hline
 & & & Venous air embolism & 1 & 4 & 1 & 5 \\
\hline
 & & & Hypothermia, temp <35° C & 22 & 70 & 26 & 160 \\
\hline
 & & & Postop intubation & 2 & 6 & 10 & 60 \\
\hline
 & & & Cardiac arrest & 0 & 0 & 0.2 & 1 \\
\hline
\end{tabular}
\end{table}

\textsuperscript{*} Bacterial and/or viral infection sites include the urinary tract, respiratory system, ophthalmic system, and/or central and mechanical intravenous lines.

\textsuperscript{†} Possible overlapping cohorts.
Strengths and Limitations

Strengths of this study include an extensive search of the current literature, strict adherence to PRISMA guidelines, and quality of evidence analysis by EPHP protocol. Currently, there exists no randomized controlled trial comparing the surgical approaches of endoscopic and open sagittal suture repair. Given the data suggesting absence of equipoise between the two techniques, it is unlikely that such a trial would be conducted. Ultimately, the findings of this meta-analysis require confirmation by larger, multicenter studies with extended follow-up.

Only 3 studies met PRISMA criteria for full meta-analysis; this low number indicates the need for future studies. The studies included in this review consisted mostly of moderate and weak observational studies. One must also consider the selection bias due to preference of surgeons or institutions and shifts of practice over time. There have yet to be any studies that examine patient or parent satisfaction, or the required duration and comfort of helmet usage. It is also evident that there is a tradeoff between the potential benefits of endoscopic repair and the disadvantage of the length of time spent in a helmet. These compromises are mediated by parental preferences, which are difficult to capture in current literature. Future studies aimed at assessing “value-based medicine” by using methodologies such as decision-tree analyses may elucidate the benefit of endoscopic repair.

Furthermore, there is still a lack of understanding regarding the variability of endoscopic outcomes and, therefore, longer follow-up and further analyses are indicated. The current meta-analysis was additionally limited by the heterogeneity of suture types in some studies. Given the clinical and surgical heterogeneity that we have identified, it is of value to conduct future observational studies that separate different entities and account for patient and surgical variability. Given the dearth of data available for meta-analysis, interstudy heterogeneity could not be calculated.

Conclusions

Endoscope-assisted correction of sagittal synostosis has some benefits over open surgical repair. Endoscopic procedures are associated with lower estimated blood loss, operating time, days in hospital, and transfusion rates. Current evidence in the literature comparing endoscopic and open sagittal craniosynostosis repair is mostly of weak to moderate quality—only 3 papers were found to be strong. Although these early studies suggest several benefits of endoscopic procedures, consideration is needed for each individual family to understand the usage of helmets and unknown long-term outcomes. Future large prospective registries or randomized controlled trials are required to validate the findings of this study.

References

Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Yan, Ibrahim. Acquisition of data: Yan, Abel, Anderson. Analysis and interpretation of data: Yan, Abel. Drafting the article: Yan, Abel, Ibrahim. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Yan. Statistical analysis: Alotaibi. Administrative/technical/material support: Ibrahim. Study supervision: Yan, Ibrahim.

Supplemental Information

Companion Papers


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