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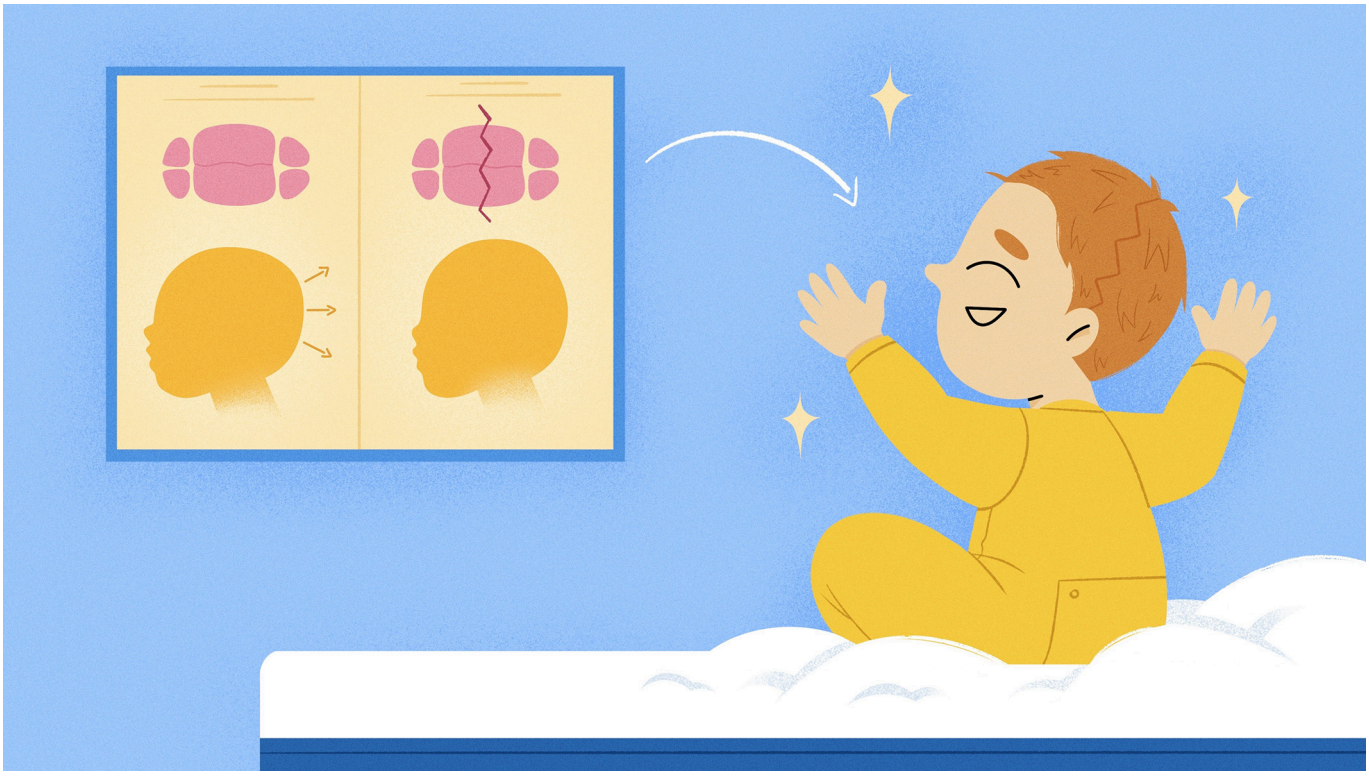
HUMAN HEALTH
Published: 14 November 2024
doi: 10.3389/frym.2024.1405421



HOW CAN SURGERY CORRECT INFANT HEAD SHAPES?

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YOUNG REVIEWERS:

ADI
AGE: 13

DIYA
AGE: 12

LETICIA
AGE: 15

YASHVY
AGE: 15

Did you know that when you are born, your skull is made of many different bones that are not fully connected yet? The reason is because when the brain grows, your skull needs to expand and grow with it. Sometimes, the bones can fuse earlier than they are supposed to, causing children around the world to be born with abnormal-looking head shapes. This condition is called craniosynostosis and occurs when the bones of the head join together too early in development. One specific type of craniosynostosis, called sagittal craniosynostosis, can greatly impact a child's health and life. There are several techniques that can be performed to improve a child's head shape. Two surgeries, a total cranial vault reconstruction (bigger surgery) and an endoscopic suturectomy (smaller surgery) have resulted in great improvements. While both surgeries can correct a child's head shape, it is important

CRANIOSYNOSTOSIS

A medical condition in which the bones of the skull come together too early, resulting in an abnormal head shape.

SUTURE

A joint connecting the bones of the skull. Sutures help the skull grow and change as the brain grows.

FUSE

The process by which the bones of the skull connect along the sutures.

SAGITTAL SUTURE

A joint connecting the parietal bones of the skull along the midline. It remains unfused for flexibility during childbirth and early brain growth in infants. It typically fuses during adulthood.

Figure 1

(A) A normal head shape, and **(B)** a sagittal craniosynostosis head shape. The images to the right of each head show the baby's skull as if you were looking down on it from the top. The left skull shows the sagittal suture unfused, while the right skull shows the sagittal future fused. The blue arrows represent the directions that the skull bones grow when the sagittal suture fuses too early in development.

to determine which surgery can provide children with the best outcomes while lowering the potential for risks or further injury.

WHAT IS SAGITTAL CRANIOSYNOSTOSIS?

When thinking about the bones that make up the skull, imagine that each bone is a piece of a puzzle. Sometimes, two of the pieces can be put together too early, making it difficult to finish the puzzle properly. Similarly, the bones in babies' heads can come together too early, resulting in head shapes that are not normal. **Craniosynostosis** is the name of the medical condition that causes the **sutures** in a baby's skull to **fuse** together too early.

Infant and adult heads have very important differences. Infants typically have thinner and less dense bones, as well as soft spots where the bones of the head are not yet joined. These differences allow a child's head to be flexible and allow room for brain growth. If a baby's skull sutures fuse too early, this can change the head's shape, increase pressure on the brain, and possibly affect developing abilities such as speech, memory, and attention. Research has also shown that children with abnormally shaped heads may be seen as "different" by others, which might affect the child's social interactions and self-esteem. Doctors can help by performing a surgery to separate the skull bones, creating more space for the brain to grow.

Sagittal craniosynostosis is the most common form of craniosynostosis. It occurs when the **sagittal suture**, which runs vertically in between the parietal bones of the skull, fuses too early in development. If the sagittal suture fuses, it can prevent the skull from growing in the right direction. As the brain grows, it causes the other sutures in the skull to move further away from each other than normal, forcing the baby's head to grow long and narrow instead of wide and round (Figure 1). Sagittal craniosynostosis occurs in about 1 out of 5,000 births and is more common in boys than girls [1, 2].

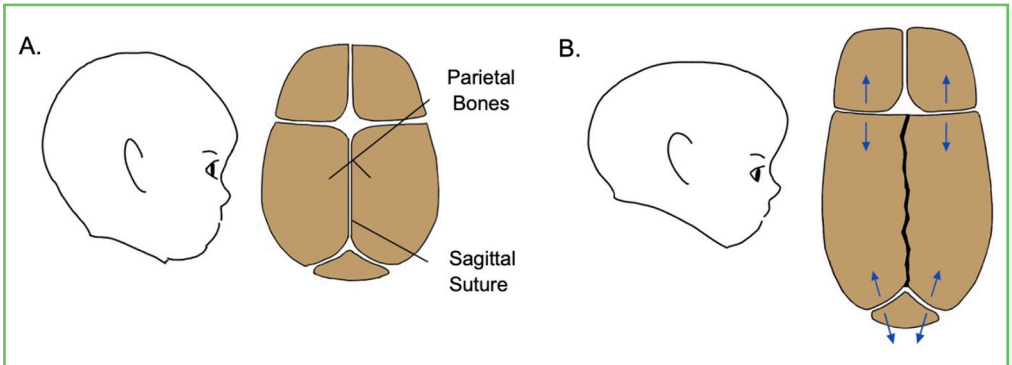

Figure 1

HOW IS SAGITTAL CRANIOSYNOSTOSIS TREATED?

TOTAL CRANIAL VAULT RECONSTRUCTION

A surgical procedure to correct craniosynostosis by carefully removing, reshaping and reattaching the bones of the skull.

There are two types of surgeries to fix sagittal craniosynostosis: **Total cranial vault reconstruction** (bigger surgery) and **endoscopic suturectomy** (smaller surgery). The bigger surgery has been used for many years to manage craniosynostosis. During the surgery, doctors make a zig-zag cut in the skin to uncover the skull bones (Figure 2A). Once uncovered, pieces of the skull are removed and rearranged to create a more normal head shape. This gives the brain enough space to grow properly. Unfortunately, the bigger surgery may cause a lot of blood loss, which can complicate the recovery process and lengthen hospital stays [3].

Figure 2

The surgical incisions (red dotted lines) that are made during **(A)** a total cranial vault reconstruction and **(B)** an endoscopic suturectomy.

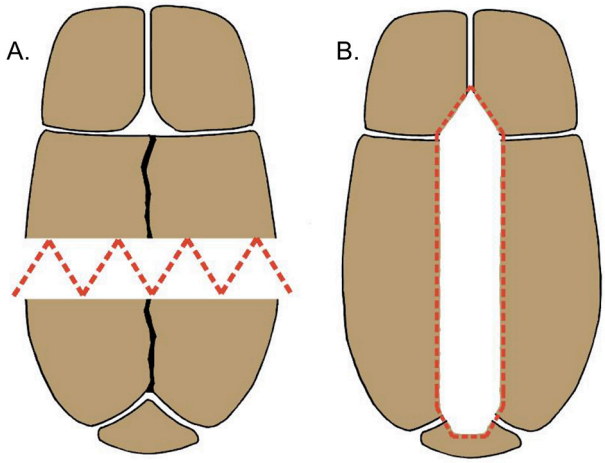

Figure 2

ENDOSCOPIC SUTURECTOMY

A minimally invasive surgical procedure to correct craniosynostosis by using a small camera and specialized tools to open up the bones of the skull that have joined too early.

The smaller surgery is newer and less expensive, involving fewer cuts and openings in the skull (Figure 2B). It depends on the skull's ability to naturally reform after surgery and is recommended for children under 4 months old. Research indicates that the smaller surgery is preferred at a younger age due to the bone being thinner and more malleable than at a later age [4]. To help visualize the operation, surgeons make small incisions in the scalp to remove the fused suture. Another key difference between the two surgeries is that after endoscopic suturectomy, doctors give the child a special helmet to wear, which helps protect the baby's skull and directs the bones to grow properly. The smaller surgery has proven to be a good alternative that can fix the baby's head shape, lower the risk of problems that may happen during surgery, and allow the child to recover faster.

WHICH IS THE BETTER SURGERY?

Since the discovery of the smaller surgery, researchers and doctors have wondered which surgery has the best outcome for patients. A previous study in 2014 compared 13 patients who had the bigger surgery and 6 patients who had the smaller surgery [5]. The

researchers determined that both procedures were equally successful in correcting head shapes.

In the current study, the results of a greater number of patients who received both procedures were documented. There were a total of 55 children (44 males and 11 females), each of which had sagittal craniosynostosis and surgeries performed at The Hospital for Sick Children in Toronto, Canada. Most of the children were around 10 months old. There were 37 children who underwent the total cranial vault reconstruction, while 18 underwent the endoscopic suturectomy. Most of the children who had the bigger surgery were 17 months old, while the majority who had the smaller surgery were under 4 months old. It is important to note that five patients out of the 55 needed additional surgery to correct their head shape.

To compare the outcomes of the surgeries, 3D photos of each child's head were captured before and after surgery, using a machine called 3dMD (Figure 3). During the 3D photo taking, each child wore a head cap to ensure that their hair did not affect the quality of the image, giving a better view of their head shape. Each 3D photo was uploaded to an editing program on hospital computers to calculate the

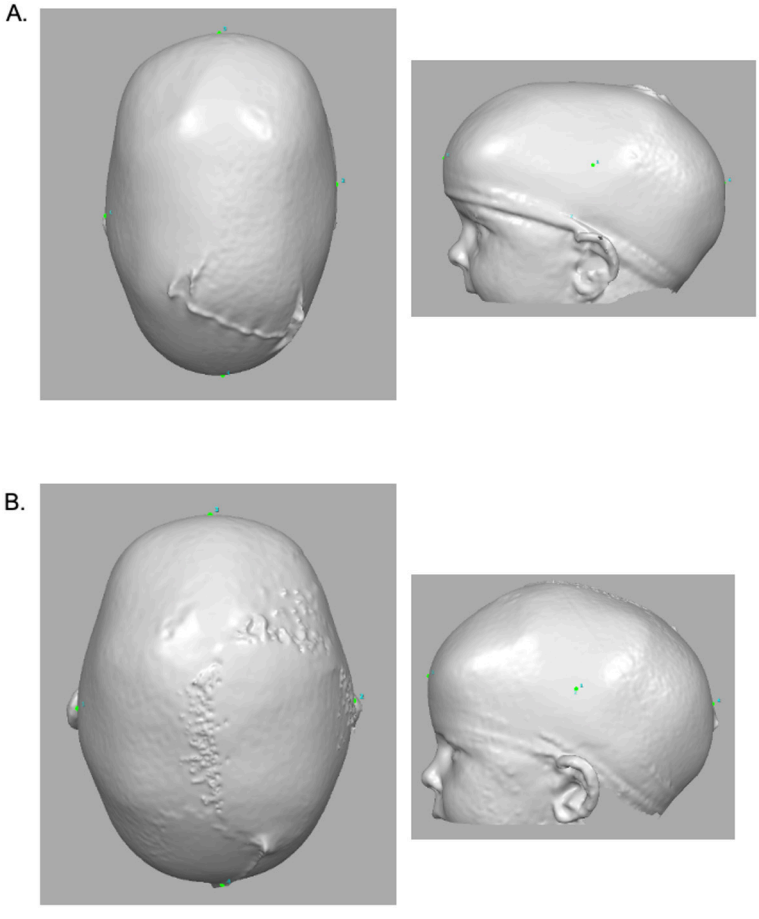

Figure 3

3D images of the head of a child diagnosed with sagittal craniosynostosis, taken **(A)** before and **(B)** after an endoscopic suturectomy [6]. Note that the roughness and irregularities are due to the 3D imaging machine and are not a result of surgery nor present on the child's head. You can see that the surgery was able to decrease the length and increase the width of the child's head, making it more of a typical, round shape.

CRANIAL INDEX

A measurement used to describe the shape of the skull. It is calculated by dividing the width of the skull by the length of the skull and multiplying by 100.

cranial index, a standard measurement representing an infant's head shape. To calculate cranial index, the researchers used a ruler feature within the program to measure the length and width of the child's head. The surgeons found that both types of surgeries could fix the head shape of each child, but the bigger surgery was slightly better in making the heads have more of a "normal" shape.

SUMMARY: WHY IS THIS IMPORTANT?

Sagittal craniosynostosis, a condition that occurs when the skull bones fuse too early, can make a child's head look long and narrow. This can cause the child to feel very different from their friends and family, which is one of the reasons why it is important to help. Sagittal craniosynostosis can also cause a lot of pressure to build up in the brain, which can make it difficult for the brain to grow properly and may lead to a variety of problems like headaches, vision loss, speech difficulties, and even memory issues. Surgeons can use two main techniques to fix sagittal craniosynostosis: cranial vault reconstruction (a bigger surgery) and endoscopic suturectomy (a smaller surgery). Doctors, surgeons, and researchers compared results of both operations and found that both surgeries could fix the childrens' head shapes to make them look more normal, ensuring that the brain could develop properly and that the children could all live healthy lives. Overall, further research is needed to compare the safety and effectiveness of each surgery. Perhaps, with advancements in the field of artificial intelligence, new technologies could be of great use in both the diagnosis of craniosynostosis and in determining which surgery offers the best outcomes.

ORIGINAL SOURCE ARTICLE

Al-Shaqsi, S. Z., Lam, N. W., Forrest, C. R., and Phillips, J. H. 2021. Endoscopic versus open total vault reconstruction of sagittal craniosynostosis. *J. Craniofac. Surg*. 32:915–9. doi: 10.1097/SCS.0000000000007307

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SUBMITTED: 22 March 2024; **ACCEPTED:** 29 October 2024;
PUBLISHED ONLINE: 14 November 2024.

EDITOR: Kunkai Su, Zhejiang University, China

SCIENCE MENTORS: Anita Singh and Paulina Buffle

CITATION: Stancati N, D'Souza G, Moss C, Phillips J and Singh D (2024) How Can Surgery Correct Infant Head Shapes? Front. Young Minds 12:1405421. doi: 10.3389/frym.2024.1405421

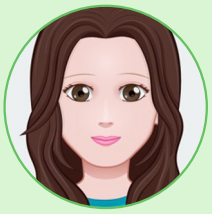
CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ADI, AGE: 13
I am a Lego enthusiast who loves science and math. I also enjoy making 3D prints of airplanes and gears. The most fun thing for me to do when not coding or 3D printing is to read about new topics in science and technology. I enjoy immersion in projects and videos of these topics that allow him to learn more about them in a fun way. I play percussion instruments and am just learning a Tenor Saxophone.

DIYA, AGE: 12

I am a proud twin who loves to listen to music and enjoy art. I am passionate about helping people who do not have access to resources that help enhance STEM learning. I help run an engineering summer camp every year and visit countries where I can share my learning. I am also a dancer and love to spend time with my fluffy dog.



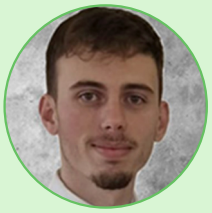
LETICIA, AGE: 15

My name is Leticia and I am fascinated by science, especially when it comes to understanding how the brain works. Neuroscience and neonatology are areas I am very interested in, and I know that pursuing a career in medicine is the path I want to follow. In my free time, I love to read, crochet, and play the piano. I also play tennis regularly, which helps keep me active and focused.

YASHVY, AGE: 15

She is a young STEM enthusiast who is interested in raising STEM awareness in youth, especially minorities. She is an artist who loves to create culturally diverse art forms. She is also engaged in promoting Youth Talent and raising funds for events that are aligned with her lifelong missions.

AUTHORS



NOAH STANCATI

Noah Stancati is a medical student at the University of Limerick, School of Medicine. He is an executive member of the Pediatric Society, Teddy Bear Hospital, and the General Practitioner Interest Group. Noah was born in Toronto, Ontario, Canada. Noah graduated from McMaster University with a B. Sc. in honors life science. He gained a strong interest in pediatric medicine and obstetrics while working in the emergency department and in research at the Hospital for Sick Children. Noah's hobbies include playing guitar, sports, and cycling. Noah hopes to couple his passions and curiosity in medicine to make lasting impacts in health care. *noah_2499@icloud.com

GINA D'SOUZA

Gina D'Souza is a medical student at the University of Limerick, School of Medicine. She received a B. Sc. in neuroscience from the University of Toronto and a M. Sc. at the Institute of Medical Science at the University of Toronto. Her research focused on using neuroimaging techniques to study patterns of neurodegeneration following traumatic brain injury and in Alzheimer's disease, to better understand the relationship between these conditions. Gina strives to share knowledge gained through research and patient interactions to improve patients' health and quality of life. In her free time, Gina enjoys baking, reading, playing soccer, and hiking.

CORINNE MOSS

Corinne Moss is a 1st-year medical student from the University of Limerick, Ireland. She has completed a Bachelor of Health Sciences at McMaster University, and a Master of Education at the University of Ottawa. Originally from Toronto, she enjoys hiking, painting, and playing with her dogs. Corinne has been working alongside the

Indigenous population for multiple years, which has spurred an interest in Indigenous health and childhood resilience. She hopes to use her medical training to continue supporting historically underserved communities.

JOHN PHILLIPS

Dr. Phillips was born in Toronto, Ontario. He received his M. D. and plastic surgery training from the University of Toronto. He is a Fellow of the Royal College of Surgeons of Canada and an associate professor at the University of Toronto. Dr. Phillips began full-time practice in pediatric craniofacial surgery at the Hospital for Sick Children in 1992. Dr. Phillips served as the medical director of The Hospital for Sick Children Craniofacial Program from 1993 to 1998. Dr. Phillips is currently using innovative imaging technology to generate a 3D computational model of the skull to refine surgical techniques.

DEVIN SINGH

Dr. Devin Singh is a leading Canadian physician in clinical AI and a pediatric emergency physician at SickKids in Toronto. With a M. Sc. in Computer Science from the University of Toronto, he combines medical and technical expertise to improve patient care. As an Assistant Professor at the university, he helps shape ethical and regulatory frameworks for AI in healthcare. Dr. Singh is currently involved in research that aims to develop technology that can accelerate the diagnosis of craniosynostosis. He is also the co-founder and CEO of Hero AI, a company developing AI tools to enhance medical decision-making. His work ensures that AI innovations are implemented responsibly, advancing healthcare through safe and ethical technology use.