Posterior cranial vault distraction osteogenesis: a literature review

Aline Rabelo Rodrigues[1] (ID), Izabella Rocha Lobo[2] (ID), Sillas Bezerra da Silva[3] (ID), Mariana Tainá Oliveira de Freitas[4] (ID), Monique Benemérita Vilela Gomes[5] (ID), Ricardo Santos de Oliveira[6] (ID), Matheus Ballestero6, [7] (ID)

[1] Universidade Federal de Jataí, Jataí, Goiás, Brasil

[2] Faculdade Souza Marques, Rio de Janeiro, Rio de Janeiro, Brasil

[3] Universidade Nove de Julho, São Paulo, São Paulo, Brasil

[4] Universidade Potiguar, Natal, Rio Grande do Norte, Brasil

[5] Universidade Federal do Piauí, Teresina, Piauí, Brasil

[6] Divisão de Neurocirurgia, Departamento de Cirurgia e Anatomia, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, São Paulo, Brasil

[7] Departamento de Medicina, Universidade Federal de São Carlos, São Carlos, Brasil

✉ Aline Rabelo Rodrigues, MD

e-mail: aline_14rabelo@hotmail.com

Available at:
http://www.archpedneurosurg.com.br/

Introduction: Craniosynostosis is a congenital condition where one or more cranial sutures close prematurely, limiting skull growth and causing cranial deformities. Posterior cranial vault distraction (PCVD) is used to relieve intracranial pressure and improve cranial aesthetics. Its incidence is about 1 in 2000–2500 live births.
Methods: This systematic review followed PRISMA guidelines. We searched PubMed, Scielo, and Lilacs for studies on PCVD in craniosynostosis, focusing on success, morbidity, and mortality. Six articles were included in the final review. Data were extracted and risk of bias was assessed using the ROBINS-I tool.
Results: The included studies reported significant increases in intracranial volume (144 mL to 281 mL) post-PCVD. Most patients showed stable results without recurrence. Complications included wound infection (29%) and cerebrospinal fluid leaks, though few required re-operations. PCVD improved intracranial pressure symptoms in most cases.
Conclusion: PCVD is an effective technique for treating craniosynostosis, increasing intracranial volume and improving symptoms of intracranial hypertension. Despite some complications, it remains a reliable and stable alternative for cranial expansion.

Keywords: neuropsychological tests, craniosynostoses, neuropsychology

INTRODUCTION

Craniosynostosis is a congenital anomaly in which one or more cranial sutures close prematurely. These sutures are essential because they allow the skull to grow as the brain develops. However, when these sutures close prematurely, the growth capacity of the brain and skull is limited, resulting in cranial deformities. The Posterior Cranial Vault Distraction procedure has become a crucial approach in the treatment of complex craniosynostosis, having two main objectives: minimizing the impacts on brain development resulting from increased intracranial pressure and improving cranial aesthetics, correcting the abnormal appearance of the skull caused by altered growth patterns. It is estimated that the occurrence of craniosynostosis is approximately one in 2000-2500 live births[1;2;3]. The objective of this article is to evaluate craniosynostosis through surgical treatment of posterior distraction of the cranial vault.

MATERIALS AND METHODS

This systematic review was made in accordance with the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) and PICOT framework.

Eligibility criteria

We included systematic reviews that studied the use of Posterior Cranial Vault Distraction in Craniosynostosis, according to three criteria: success, morbidity, and mortality. Articles published in languages other than English, Portuguese, or Spanish were excluded from the review.

Search strategy

Full Articles were selected on the platform "PUBMED", Scielo e Lilacs, between 01/04/2024 and 06/04/2024, using the following search terms: "Posterior Cranial Vault Distraction", "Craniosynostosis". These search terms were connected using the boolean operator "AND". Additionally, reference tracking of the searched articles was carried out to identify other relevant articles that were missed during the initial search. We excluded duplicate studies, abstracts, and editor letters from the final search. The articles were screened for review by two independent reviewers. 152 articles were initially found, and, out of these, 6 entered this review.

Data extraction

The selected articles were analyzed by three independent reviewers. Qualitative and quantitative data from each study were extracted into a Google Sheets sheet. Details of authors, publication dates and country, number of included studies, sample size, surgical approach, outcome, mortality, and morbidity were extracted from the selected systematic reviews. Quantitative information was used to conduct this systematic review and qualitative data regarding key findings, strengths, and limitations of the studies were noted from each review.

Disagreements regarding any information to be extracted were resolved by discussion and mutual agreement.

Risk of bias

We assessed the risk of bias in non-randomized studies of interventions (NRSI), we employed the Risk of Bias in Nonrandomized Studies of Interventions (ROBINS-I) tool. As recommended, our approach juxtaposed an ideal, feasible randomized clinical trial with NRSIs. The assessment of bias involved two independent reviewers. In instances of discordance, a third reviewer adjudicated after team discussion.

RESULTS

Study selection

We identified 152 articles available in the three databases and retrieved 149 articles after removing duplicates. Forty-one studies were selected for full-text analysis, and six were included for systematic review. Among them, all were identified as NRSI (Figure 1)
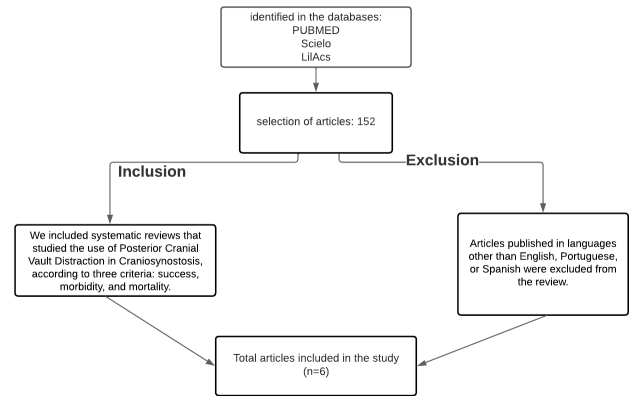
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Figure 1 – Revision PRISMA Flow Diagram.

DISCUSSION

Posterior cranial vault distraction (PCVD) was first described in 2009 by White et al. and has since become widely used in syndromic craniosynostosis. Recently, the technique has been employed as an alternative to fronto-orbital advancement (FOA) or anterior cranial vault expansion.

PCVD is indicated in cases where brain herniations and changes in brain mass must be avoided. In patients with craniosynostosis, PCVD allows for decompression of the foramen magnum (FMD), increasing the volume of the dural sinuses and improving venous flow, particularly in patients with syndromic craniosynostosis. According to a study by Cinalli et al., they evaluated the effects of posterior cranial vault distraction (PCVD) combined with foramen magnum decompression (FMD) on the volume of the dural sinuses and venous flow in five patients with syndromic craniosynostosis. The volumes of the sagittal, straight, transverse, and sigmoid sinuses were measured using preoperative and postoperative T2 magnetic resonance imaging, with three-dimensional image reconstruction of phase-contrast magnetic resonance angiography (PC-MRA) images, achieving multiplanar reconstruction (MPR). The results showed an increase in the average total volume of all dural sinuses immediately after surgery (from 10.06 cm³ to 12.64 cm³), and this expansion continued for 30 days. The right sigmoid sinus (+33.7%) and straight sinus (+23.4%) remained stable after the initial increase. Significant volume increases were observed in the left transverse sinus (+113.2%), right transverse sinus (+104.3%), left sigmoid sinus (+91.3%), and sagittal sinus (+41.8%). Four patients showed improvement in venous flow, while one remained stable. All patients had chronic tonsillar herniation (CTH), and three had syringomyelia. Post-surgically, CTH improved in four patients, but worsened in one. Syringomyelia improved in two patients and remained unchanged in one.

Additionally, Azusa et al. analyzed intracranial volume changes after PCVD and compared the effectiveness of different surgical procedures, including fronto-orbital advancement (FOA) and anterior cranial vault expansion. They studied seven patients with craniosynostosis who underwent posterior cranial vault distraction. Total posterior skull expansion was achieved in four patients who underwent frontal remodeling and in one patient with FOA using distraction osteogenesis. Intracranial volume was measured using preoperative and postoperative three-dimensional (3D) computed tomography (CT), performed the day before the first surgery and after the second. Intracranial content and total intracranial volume were calculated using the radiation workstation (Ziostation, Ziosoft Inc., Tokyo, Japan). The amount of distraction was measured by lateral radiographs and extension records. The procedure resulted in an average length of distraction of 31 mm (ranging from 22.3 mm to 39 mm) and an increase in intracranial volume ranging from 144 mL to 281 mL (average increase of 192 mL). No recurrences were observed, and intracranial volumes remained within normal ranges in all patients.

Gregori et al. described a study involving 31 patients with severe brachycephaly or turribrachycephaly who underwent PCVD. Twenty-three patients underwent PCVD as a primary procedure at an average age of 8 months, while eight patients underwent PCVD as a secondary procedure at an average age of 2 years. Total distraction of 20 mm was achieved in 28 patients, with only one patient showing no improvement in symptoms of increased intracranial pressure.

Satanin et al. reported the use of resorbable sonic pins for fixation of distraction devices in posterior cranial vault distraction operations for intracranial volume gain in craniosynostosis patients. Resorbable sonic pins were used in 11 procedures to fix the distraction devices to the calvarial bone after posterior distraction. Three patients experienced displacement of the proximal distractor platform and partial recurrence of the distraction, leading to smaller volume gains compared to other techniques, although none required reoperation.

Wiberg et al. described a retrospective study of 10 patients who underwent posterior distraction, with an average advancement of 19.7 mm in the calvarium in all cases. Nowinski et al. discussed the case of a premature infant born at 32 weeks with a weight of 1,330 g and a head circumference of 28 cm, who presented with bicoronal synostosis. Surgical planning involved the use of computed tomography with 1.24 mm axial slices and SurgiCase software to define the osteotomy and limit the extent of posterior bone traction. They were able to calculate the increase in intracranial volume using this software. During surgery, virtual plans were used as a guide. A bicoronal zigzag incision was made, the scalp flap was raised in the subgaleal

plane, and distractors were placed and fixed with 3.5 mm metal screws, exposed in the temporal region. Blood loss was approximately 40 mL. The procedure resulted in successful cranial vault expansion with a reduction in complications.

CONCLUSION

Posterior cranial vault distraction is an effective surgical method for treating craniosynostosis, especially in syndromic or complex cases. The technique not only significantly increases intracranial volume, but also improves venous flow in dural sinuses, alleviates symptoms associated with increased intracranial pressure, and enhances cranial aesthetics by correcting abnormal skull shapes. Despite some reported complications like distractor displacement, the majority of patients experienced minimal morbidity, and no mortality was associated with the procedure in the analyzed studies. Therefore, PCVD presents a valuable alternative to traditional techniques such as fronto-orbital advancement, offering both functional and aesthetic benefits and contributing to better neurological outcomes and quality of life for patients with craniosynostosis.

CONTRIBUTIONS

Aline Rabelo Rodrigues : Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Visualization, Writing –original draft, Writing –review & editing

Mariana Tainá Oliveira de Freitas: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation,

Methodology, Project administration, Software, Visualization, Writing –original draft, Writing –review & editing

Sillas Bezerra da Silva: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Visualization, Writing –original draft, Writing –review & editing

Monique Benemérita Vilela Gomes: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Visualization, Writing –original draft, Writing –review & editing

Izabella Rocha Lobo: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Visualization, Writing –original draft, Writing –review & editing

Ricardo Santos de Oliveira: Conceptualization, Project administration, Validation.

Matheus Ballestero : Project administration, Resources, Software, Supervision, Validation, Visualization, Project administration, Writing –original draft, Writing –review & editing.

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