"To Evaluate Extent Of Decompressive Craniectomy With Help Of Volumetric Analysis To Assess Adequacy Of Decompression"

Sumit Kumar Kansal[1]Raghavan Iyengar[2], Gourav Jatav[2], Prakash Goswami[3], Alok Kumar[3], Vikas Warwade[1]

Senior resident[1] Associate professor[2] Assistant professor[3],
Corresponding author-Sumit Kumar Kansal
Department Of Neurosurgery, Sri Aurobindo Medical College &Pg Institute, Indore, Madhya Pradesh, India.

Abstract
Background: Decompressive craniectomy (DC) has emerged as a vital intervention for various neurological conditions, aiming to alleviate intracranial pressure and improve patient outcomes. However, the optimal extent of decompression remains debatable, balancing the benefits of reducing intracranial pressure against the risks of complications such as paradoxical herniation. This study aimed to assess the adequacy of decompression following DC using volumetric analysis, aiming to provide objective measurements of intracranial volume changes and their association with patient outcomes.
Material and Method: The study was conducted prospectively among patients undergoing decompressive craniotomy at a specified hospital. Demographic details, physical examinations, and volumetric measurements were obtained. Statistical analysis was performed using SPSS v23.0, including mean differences and correlations.
Result: Twenty patients were included, with a mean age of 37.45 years and a male preponderance. Significant negative correlation was observed between surface estimate and brain volume outside, with significant positive associations noted for anterior-posterior, cranio-caudal measurements, and total calvarial volume. Patients who experienced mortality had a significantly higher mean total calvarial volume compared to survivors.
Conclusion: This study documented a mortality rate of 30%, with a significant association between higher total calvarial volume and mortality. Volumetric analysis provides valuable insights into the adequacy of decompression following DC, aiding in clinical decision-making and patient management strategies.
Keywords:Decompressive craniectomy, Volumetric analysis, Brain volume, Total calvarial volume, Mortality, Patient outcomes.*

I.   Introduction:

Decompressive craniectomy (DC) has become a crucial therapeutic intervention in the management of various neurological conditions, including traumatic brain injury, stroke, and intracranial hypertension. This surgical procedure involves removing a portion of the skull to alleviate intracranial pressure, thereby mitigating the risk of secondary brain injury and improving overall outcomes.(1)

However, the optimal extent of decompression achieved through DC remains a subject of debate among neurosurgeons. While complete decompression may be desirable in some cases to effectively lower intracranial pressure and prevent further neurological deterioration, excessive decompression can lead to complications such as the "sinking skin flap syndrome" or "syndrome of the trephined," characterized by paradoxical herniation and neurological deficits.(2)

In recent years, volumetric analysis techniques have emerged as valuable tools for evaluating the adequacy of decompression following DC.(3,4) These quantitative methods, often utilizing advanced neuroimaging modalities such as computed tomography (CT) or magnetic resonance imaging (MRI), enable precise measurement of intracranial volumes before and after surgery, allowing for objective assessment of the degree of brain decompression achieved.(5)The importance of accurately assessing the extent of decompression lies in optimizing patient outcomes and guiding clinical decision-making.(6,7) By determining the adequacy of decompression, clinicians can tailor postoperative management strategies, such as the timing of skull reconstruction or the initiation of rehabilitative interventions, to promote favourable neurological recovery and minimize complications.(8)

In this context, further research focusing on the application of volumetric analysis techniques to evaluate the extent of decompression following DC is warranted. Such studies hold the potential to enhance our understanding of the relationship between surgical decompression and clinical outcomes, ultimately informing the development of evidence-based guidelines for the management of patients undergoing DC.

II. Material & Method:

The present prospective observational study was conducted among the patients undergoing decompressive craniotomy, at Sri Aurobindo institute of medical science hospital. Study was conducted after obtaining informed consent from the patients attender and institutional ethics clearance was obtained priorly. The study, included all the patients undergoing the decompressive craniotomy. All the patient's demographic details such as age, gender, occupation, cause of trauma, past history, physical examination and systemic examination was conducted. The volumetric measurements were done among the patients and analysed.

Statistical analysis: all the data were entered in excel sheet and analysed using SPSS v23.0. The data were summarised as mean, standard deviation, frequency and percentage. The mean difference between parameter were measured using unpaired t-test and correlation between continuous data was analysed using Pearson's correlation. For all statistical purpose a p-value less than 0.05 was considered statistically significant.

III. Result:

Total of 20 patients fulfilling inclusion criteria are included with mean age of 37.45±13.06yrs. Among them 70% were male patients (n=14) and 30% were female patients (n=6), with male preponderance.

On Pearson's correlation between the parameters there was significant negative relation of surface estimate with brain volume outside and significant positive association with Ant post, cranio-caudal measurement, and total calvarial volume among the patients (p<0.05)

Table 1: Correlation between the volumetric measurement

		Total Brain Volume (Cm3)	Brain Volume Outside (Cm3)	Antpost	Cranio-Caudal	Total CalvarialVol (Cm3)	Surface Estimate
Total Brain Volume (Cm3)	r	1	-.308	.203	.016	.496[*]	.134
	Sig		.186	.390	.947	.026	.572
Brain Volume Outside (Cm3)	r	-.308	1	-.229	-.636[**]	-.328	-.515[*]
	Sig	.186		.332	.003	.157	.020
Ant-Post	r	.203	-.229	1	.476[*]	.272	.851[**]
	Sig	.390	.332		.034	.246	.000
Cranio Caudal	r	.016	-.636[**]	.476[*]	1	.283	.866[**]
	Sig	.947	.003	.034		.227	.000
Total CalvarialVoL (Cm3)	r	.496[*]	-.328	.272	.283	1	.333
	Sig	.026	.157	.246	.227		.152
Surface Estimate	r	.134	-.515[*]	.851[**]	.866[**]	.333	1
	Sig	.572	.020	.000	.000	.152	

Table 1: Comparison of outcome with volumetric measurements

	OUTCOME				p-value
	Death		Live		
	Mean	SD	Mean	SD	
Total Brain Volume (Cm3)	1265	34	1103	298	0.20
Brain Volume Outside (Cm3)	38.5	22.2	41.5	16.8	0.74
Antpost	12.7	1.1	13.3	.7	0.154
Cranio Caudal	10.1	.8	10.7	.6	0.08
Total CalvarialVol (cm3)	1526.2	72.3	1392.9	137.7	0.04*
Surface Estimate	100.701	13.627	112.184	11.460	0.068

There is significant higher mean level of total calvarial volume in patients with mortality compared to patients alive.(p<0.05)

IV. Discussion:

Evaluating the extent of decompressive craniectomy (DC) through volumetric analysis offers several benefits in assessing the adequacy of decompression.(9) By providing precise quantitative measurements of intracranial volume changes before and after surgery, volumetric analysis allows for objective assessment of the effectiveness of DC in alleviating intracranial pressure. This quantitative approach enables clinicians to tailor postoperative management strategies based on the degree of decompression achieved, thereby optimizing

patient outcomes and reducing the risk of complications such as cerebral herniation or secondary brain injury.(10) Additionally, volumetric analysis facilitates longitudinal monitoring of intracranial volume changes over time, providing valuable insights into the dynamics of brain tissue edema and recovery following DC. Overall, incorporating volumetric analysis into the evaluation of DC outcomes enhances clinical decision-making and improves patient care.

Study by Kitis S et al., documented that the removed bone are was found to be significantly related with outcome of the patients. (11) In their long-term follow-up study of patients who underwent craniectomy exceeding 14 cm, Walz and colleagues observed that severe disability was present in only 8.3% of patients, with the majority experiencing mild to moderate disability.(12) The present study documented a mortality rate of 30% among patients, emphasizing the significant impact of the condition. Additionally, patients who experienced mortality exhibited a significantly higher mean total Calvarial volume compared to those who survived, highlighting a potential association between cranial volume and patient outcomes.

V. Conclusion:

Study documented 30 percent of patients with mortality, and there was significant higher mean of total Calvarial volume in patients with mortality compared to alive patients.

Funding: Nil
Conflict of interest: Nil

Reference:

[1]. Hutchinson Pj, Kolias Ag, Timofeev Is, Corteen Ea, Czosnyka M, Timothy J, Et Al. Trial Of Decompressive Craniectomy For Traumatic Intracranial Hypertension. N Engl J Med. 2016;375(12):1119–30.
[2]. Honeybul S, Ho Km, Lind Crp. What Can Be Learned From The Decra Study. World Neurosurg. 2013;79(1):159–61.
[3]. Sahuquillo J, Dennis Ja. Decompressive Craniectomy For The Treatment Of High Intracranial Pressure In Closed Traumatic Brain Injury. Cochrane Database Syst Rev. 2019 Dec;12(12):Cd003983.
[4]. Wilson Jr, Tetreault La, Kwon Bk, Arnold Pm, Mroz Te, Shaffrey C, Et Al. Timing Of Decompression In Patients With Acute Spinal Cord Injury: A Systematic Review. Glob Spine J. 2017 Sep;7(3 Suppl):95s-115s.
[5]. Jiang J-Y, Xu W, Li W-P, Xu W-H, Zhang J, Bao Y-H, Et Al. Efficacy Of Standard Trauma Craniectomy For Refractory Intracranial Hypertension With Severe Traumatic Brain Injury: A Multicenter, Prospective, Randomized Controlled Study. J Neurotrauma. 2005;22(6):623–8.
[6]. Sunderland G, Foster M, Dheerendra S, Pillay R. Patient-Reported Outcomes Following Lumbar Decompression Surgery: A Review Of 2699 Cases. Glob Spine J. 2021 Mar;11(2):172–9.
[7]. Rigoard P, Gatzinsky K, Deneuville J-P, Duyvendak W, Naiditch N, Van Buyten J-P, Et Al. Optimizing The Management And Outcomes Of Failed Back Surgery Syndrome: A Consensus Statement On Definition And Outlines For Patient Assessment. Pain Res Manag. 2019;2019:3126464.
[8]. Ndiaye Sy Ehc, Cisse Y, Thiam Ab, Barry Lf, Mbaye M, Diop A, Et Al. Decompressive Craniectomy: Indications And Results Of 24 Cases At The Neurosurgery Clinic Of Fann University Hospital Of Dakar. Pan Afr Med J. 2021;38:399.
[9]. Alvis-Miranda H, Castellar-Leones Sm, Moscote-Salazar Lr. Decompressive Craniectomy And Traumatic Brain Injury: A Review. Bull Emerg Trauma. 2013 Apr;1(2):60–8.
[10]. Kim Jh, Choo Y-H, Jeong H, Kim M, Ha Ej, Oh J, Et Al. Recent Updates On Controversies In Decompressive Craniectomy And Cranioplasty: Physiological Effect, Indication, Complication, And Management. Korean J Neurotrauma. 2023 Jun;19(2):128–48.
[11]. Kitiş S, Çevik S, Köse Kb, Baygül A, Cömert S, Ünsal Üü, Et Al. Clinical Evaluation Of Decompressive Craniectomy In Malignant Middle Cerebral Artery Infarction Using 3d Area And Volume Calculations. Ann Indian Acad Neurol. 2021;24(4):513–7.
[12]. Walz B, Zimmermann C, Böttger S, Haberl Rl. Prognosis Of Patients After Hemicraniectomy In Malignant Middle Cerebral Artery Infarction. J Neurol. 2002 Sep;249(9):1183–90.