Single-Step Ladder Expansive Cranioplasty: 2-Year Follow-up

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Decompressive hemicraniectomy is often resorted to in cases of severe head injury to deal with, and sometimes in anticipation of, a refractory raised intracranial pressure (ICP). With progressively reducing acceptable time interval between the primary surgery and cranioplasty, concerns regarding trephination syndrome and injury to the unprotected brain have substantially reduced. However, there still remains the necessity of bone flap preservation and a second surgery with its monetary and logistic implications that some patients can ill afford. With a view to devise a surgical technique that can accomplish the aim of achieving adequate intracranial volume expansion required to mitigate the raised ICP without having to subject the patient to a second surgery at a later date, “step ladder expansive cranioplasty” was conceptualized¹ and performed on a patient with acute subdural hematoma (SDH) and was published in *Indian Journal of Neurosurgery* as a technical note after 3 months of uneventful follow-up.² We have subsequently followed up the patient for 2 years.

Clinical Summary

A 72-year-old man with multiple comorbidities was admitted with history of head injury with a Glasgow coma scale (GCS) score of $E_2V_2M_5$, in absence of any lateralizing signs. Noncontrast computed tomography (NCCT) of the head revealed an acute right-sided fronto-parieto-temporal SDH with a 10.2-mm midline shift and effacement of the basal cistern (► Fig. 1A, B). The patient was taken up for a “single-step ladder cranioplasty,” with written informed consent from the next of kin. The craniectomy defect in this patient was 12 cm × 8 cm in size. The volume of dural outpouching in this patient, when measured from the craniectomy margin (using formula $2/3 \times \text{surface area of the defect} \times \text{height of the dural outpouching from the craniectomy defect}$) was 141.28 cm³. He was discharged from the hospital with a GCS of $E_4M_6V_5$ and without any focal neurologic deficit. Individual subsequently

presented with generalized tonic-clonic seizures and was detected to have developed a chronic fronto-parieto-temporal SDH (► Fig. 1C) requiring a single burr hole and drainage under local anesthesia. Subsequent recovery has been uneventful. Two years after surgery, he is comfortable with his obvious step deformity in the scalp (► Fig. 2), not keen to undergo any corrective surgery for the same. NCCT of the head shows no feature of implant failure (► Fig. 1D). There is a near-complete resolution of the cerebrospinal fluid (CSF) hygroma recorded in the NCCT of the head obtained on third week after surgery (► Fig. 1E), and the brain appears to have expanded to occupy nearly the entire available space in the volume-augmented cranium (► Fig. 1F).

Discussion

The maximum volume expansions achieved in this case was 141.28 cm³, as compared to the cases of unilateral decompressive hemicraniectomy recorded by Cavuşoğlu et al and Olivecrona et al to be of 102.7 cm³ and 109 cm³, respectively. Though the study by Münch et al recorded 157.6 cm³ as the maximum volume expansion achieved, the mean volume expansion reported was 92.6 cm³.^{3–5}

The volume-augmented cranium has an expanded surface area to cover and leaving any open wound or suture line under stress over a craniotomy would have disastrous consequences. Rotation scalp flap was successfully used to cover the defect.

Conclusion

Step ladder expansive cranioplasty offers a single-stage alternative that reinstates Monroe Kelley doctrine while achieving an assured intracranial volume augmentation that can be optimized based on our experience in the future. In patients uncomfortable with the cosmesis, taking down the construct at a later date will probably be easier than a routine

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Fig. 1 Single-step ladder expansive cranioplasty: the index case. **(A, B)** Axial sections of preoperative NCCT scan image of head. **(C)** Contralateral chronic SDH with significant mass effect evident in 16 weeks postoperative NCCT image. **(D)** Intact cranioplasty construct 18 months after surgery showing step ladder expansion achieved by fixing the cranium and the bone flaps on two opposite surfaces of the titanium miniplates, thereby displacing the bone flap laterally from its preoperative position. **(E)** Contralateral CSF hygroma evident in 8 weeks postoperative NCCT of the head. **(F)** Eighteen months post surgery NCCT of the head.

Fig. 2 Cosmesis: obvious step deformity.

cranioplasty. Further clinical trial is required to see whether this case results are reproducible, once a consensus can be achieved on the volume expansion required to mitigate the raised ICP in different cases.

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Conflict of Interest

None declared.

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