**Original Article**

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# Limited Fronto-Temporo-Parietal Craniectomy in Traumatic Brain Injury: My Experience

Amidst the uncertainty of benefit of decompressive craniectomy (DC) in severe traumatic brain injury (TBI), the procedure is still widely performed as a life saving attempt. Different types of DC have been described. A timely performed limited fronto-temporo-parietal (FTP) decompression is found to be adequate enough to reduce the intracranial pressure (ICP) quickly and sufficiently, preventing medial temporal herniation. This can be further augmented by an adequate, liberal and watertight duroplasty to accommodate the swollen injured brain, which can be achieved by using patients' own tissues like thickened subcutaneous areolar tissue and temporalis fascia. DC is usually considered as a two-step surgery where decompression is done in the first step and cranioplasty in the second. It can be made a single step surgery by replacing the bone in small pieces extradurally during the primary surgery itself, to avoid second surgery (cranioplasty). The details of the procedure and its results have been described and review of related literature has been done.

**Key Words:** cranioplasty, decompressive craniectomy, duroplasty, intracranial pressure

Management of traumatic brain injury revolves around the timely and efficiently controlled intracranial pressure. Persistently high intracranial pressure (>20 mm Hg) is the most common cause of death and disability in traumatic brain injury.22 When medical management fails to reduce the raised ICP, a timely performed surgery like decompressive craniotomy becomes a life saving procedure. The rationale for this procedure is based on the Monro-Kellie Doctrine, i.e. expanding the intradural space will reduce intracranial pressure in TBI. DC thus is indicated in traumatic brain injury (TBI) with malignant intracranial hypertension (ICP) where medical therapy alone cannot reduce intracranial pressure adequately to prevent medial temporal herniation.21 The benefits of DC directly depend upon surgical technique and degree of decompression achieved.28 The goal of DC is to provide adequate bony decompression of the anterior and middle fossa without compromising dural venous drainage.28 Profound variability exists in surgical technique, and to date there are no technical papers that establish a consistent methodology for DC. It is observed that in moderate to severe TBI with uncontrolled ICP, a limited FTP decompression with liberal duroplasty can reduce the ICP quickly, significantly and sufficiently, giving results similar to a larger decompressive craniotomy.

## Materials and Methods

From 2007 to 2014, 104 cases of TBI with indication for decompressive craniectomy presented to Emergency Department of our Hospital. At presentation, according to Glasgow coma scale, 14 had mild, 34 had moderate and 56 had severe TBI. The age ranged from 14 to 79 years and almost 75% were male. After resuscitation and investigations, it was found that 78 patients had indications to undergo the DC on the same day. The rest of the 26 patients, who were initially managed conservatively, had to be operated within 48 hours as they showed clinical and radiological evidence of deterioration. It is interesting to note that this included 14 cases of mild TBI who rapidly deteriorated and needed the surgery.

When DC was planned, informed consent was obtained from the relatives. ICP was not measured nor monitored, as the facility was not available in our center. These patients underwent limited FTP craniectomy, evacuation of hematoma, liberal duroplasty and replacement of the bone in small pieces. In 25 cases, the procedure was performed bilaterally.

The detail of the surgery is described as follows: After administrating general anaesthesia, the patient was placed in supine position with the head turned laterally with the temporal area facing upwards. A vertical skin incision of 15cm was made, 1cm anterior to tragus from zygoma level upwards. After giving the skin incision, the subcutaneous layer was defined which was thickened by the inflammatory reaction of trauma. A patch of the layer of about 8cm diameter was dissected and taken out. The temporalis fascia was harvested for duroplasty. Temporalis muscle was cut with a cautery along the line of incision upto the zygomatic arch. It was dissected and retracted laterally exposing fronto-temporo-parietal bone of about 12cm diameter. A burr hole was made and using a nibbler, rest of the bones was removed in small pieces down to the floor of the middle cranial fossa, at the root of the zygoma. This ensures adequate lateral decompression of the temporal lobe, allowing it to “fall out” of its usual calvarial boundaries. The dura was opened by multiple radial incisions. Subdural haematoma and superficial intracerebral haematoma were removed. Haemostasis was achieved. Duroplasty was done using the temporalis fascia and the patch of tissue obtained from subcutaneous areolar layer. The bone pieces were washed, lightly placed extradurally in the area of bone defect and covered by a thin layer of Gel foam. Temporalis muscle, which was very loose and elastic in the absence of temporalis fascia, was approximated and loosely stitched together. The overlying skin was undermined and stitched in two layers. A floppy and loose dressing was applied and covered with a loose adhesive tape.

All the surgeries were uneventful. The blood loss was in average, 250ml and none required intra-operative blood transfusion. Duration of surgery in unilateral case was in average 85 minutes and 135 minutes in bilateral cases.

Postoperatively, all were initially managed in ICU. Eighty-four of them were placed in the ventilator and were gradually weaned off. They were later shifted to Neuro-ICU and then to the general ward as the consciousness and general condition got improved. Tracheostomy was done in 74 patients within 72 hours which facilitated weaning off the ventilator, better tracheo-bronchial toileting, quicker improvement in conscious level, a shorter ICU stay and a better outcome. To assess the progress and to detect complications early, serial CT scan of brain was performed on 2nd, 7th, 10thpostoperative days and then every week till discharge or earlier if needed.

Seven of them developed wound infection. The wound was explored under local anaesthesia and the bone pieces were removed. Antibiotics were put according to the culture report. One patient developed septicaemia, multi-organ failure and expired. The rest recovered well and were discharged. Cranioplasty using methylmethacrylate was done after six months.

Small contusions were not excised with the fear of damage to normal brain. In 48 (46%) patients the hemorrhagic contusion was seen to be increased. Since the clinical condition did not significantly deteriorate, none of them required an additional surgical intervention.

Symptomatic Hydrocephalus developed in 11 (10.5%) patients. 6 of them were detected during the same hospital stay and the rest 5 were detected in follow up. They underwent Ventriculo-Peritoneal shunt. The shunt was placed on the opposite side to that of craniectomy.

Almost all developed some amount of subdural collection, which was the most common complication of this surgery. However none of them required any surgical intervention, as there was no appearance of fresh focal deficit or deterioration in neurological status. The duration of hospital stay was 16 days to 96 days with mean of 26 days. The Glasgow Outcome Scale at the time of discharge was; Good recovery in 14, Moderate recovery in 68 and Severe disability in 13. 19 patients died, mainly from septicaemia and multiple organ failure. In none of these patients, it was felt that the decompression was inadequate and none had to be re-operated for the reason.

## Discussion

The management of traumatic brain injury (TBI) revolves around the effective and timely control of intracranial pressure (ICP). The control of ICP is done at first by non-surgical methods. Surgical intervention is needed only in 5 to 15% of total patients with TBI where medical management alone fails or is likely to fail to control ICP. For expected prognosis, timely recognition of failure of medical therapy and quick surgical intervention is very important. Decompressive craniectomy (DC) is one of the surgical procedures to lower down ICP quickly and effectively by 20 to 30 mm of Hg where haematoma can also be evacuated and haemostasis can be achieved at the same time.7,23 DC is the most radical intervention to reduce intracranial hypertension quickly and to protect the viable brain tissue from getting damaged. In more than 85% of case of high ICP, refractory to conventional medical treatment, DC reduces ICP effectively and quickly.2,12,27 The Brain Trauma Foundation (BTF) and the Brain Injury Consortium (BIC) consider DC as a second- tier therapy for medically intractable intracranial hypertension.4,6

Decompressive surgery was performed since 1905 in TBI and it was popularized after 1970s for medically refractory intracranial hypertension caused by trauma, infarction, haemorrhage, etc. 8,9,18 Decompressive craniotomy is the surgical removal of a part of the calvaria followed by liberal duroplasty.37 It creates a window in the cranial vault to increase the volumetric compensatory capacity and to reduce ICP. It allows expansion of the edematous cerebrum by adding a vector of expansion to the cerebral hemispheres and relieves or prevents brain herniation. It interrupts the vicious cycle of intracranial hypertension, impairment of the cerebral perfusion pressure (CPP), leading to further increase in ICP, cellular injury and death.19,33 It also increases collateral cerebral circulation and thus helps in reduction in tissue edema, improvement in oxygenation and energy metabolism.11,35,36,40 Although decompression does not reverse the primary brain injury, it can reduce and prevent further brain damage caused by persistently raised ICP. Surgical intervention is thus done before irreversible brain stem damage or generalized ischemic brain damage occurs, i.e. usually before 48 hours of the injury.27,29 In this series, all the DC were performed within 48 hours. Patients with primary fatal brainstem injury, an initial and persisting GCS score of 3 and / or bilaterally dilated and fixed pupils, are not candidates for the surgery.12

For more than a century, DC has been performed in these desperate situations to save lives. However ill-defined indications, uncertainty of timing of the surgery, unsure role of ICP monitoring, controversy of ideal size of decompression, doubtful benefits in terms of functional outcom and different results from different centers, has created doubts on the real advantage of this surgery.6,10,14,25 Cochrane data base analysis in 2007 concluded that there was no evidence to support the routine use of DC to reduce unfavorable outcome in adults suffering from severe TBI with refractory intracranial hypertension.30 However in pediatric trauma patients the study showed that DC seems to reduce the risk of death and unfavorable outcome.29 To ascertain the benefit of surgery and to establish a consistent methodology for performing decompressive craniectomies, two studies, The early DEcompressive CRAniectomy (DECRA) trial and The Randomized Evaluation of Surgery with Craniectomy for Uncontrollable Elevation of Intra-Cranial Pressure trial (The RESCUE ICP trial) are going on.6,16 Till then we will have to depend on one’s experience, available literature and belief, to decide on the indications and benefit of the surgery.

Many types and size of craniectomy are performed with their individual merits and demerits. Different types and sizes of craniectomies can increase the volume ranging from 26 to 92 cc.15 Though it is said that larger the craniectomy, greater is the reduction of ICP, large craniectomy has greater complications of the procedure including greater disturbances in homeostasis of brain, CSF dynamics and cerebral blood circulations.17,34 However, small craniectomy would not allow adequate window for the injured brain to swell and reduce ICP.15 Thus decision on the appropriate type and size of DC needs to be ascertained for optimizing the ICP lowering effects of the operation with consideration of duration, cost and technicality of the surgical procedure. In this series we have seen that even a limited Fronto-temporo-parietal craniectomy can reduce the ICP quickly and provide adequate decompressive volume without compromising the benefits of a larger craniectomy.

Liberal, adequate and watertight duroplasty to make a large durotomy “bag” is an important aspect of the success of the surgery.15 Different types of synthetic materials are available for duroplasty, like the waterproof fabric Gore-Tex (27,41) and various silicone-based materials.5,20,24,38 Many neurosurgeons use DuraGen or Durepair, allogeneic collagen matrices that can be sutured into position or used as an onlay graft in the subdural or epidural space. However, patients’ own tissue is always preferred which is readily available with no extra cost. Using temporalis fascia as a dural substitute is long being practiced. It is tough and available in the same surgical site. However, the size available is not adequate for a liberal duroplasty. A supplementary patch of almost 8 cm diameter can be obtained from subcutaneous areolar layer, which is thickened by the inflammatory reaction of trauma. Though the subcutaneous layer is not a very tough structure, the tissue serves as an addition tissue for duroplasty. Reports of using galea aponeurotica are present but harvesting thickened loose areolar tissue is much easier and faster.12 Using the temporalis fascia and subcutaneous areolar layer, the swollen brain can be easily accommodated without any tension on closure.

The bone window created during craniectomy gives a space for the injured brain to swell outside laterally relieving the pressure exerted medially towards the normal brain. Usually it takes around six weeks or more for the swelling to subside before a cranioplasty is done. Thus this surgery is considered to be a two-staged surgery. At first, the swollen traumatized brain is decompressed by performing decompressive craniectomy. In the second stage, at almost one to two months interval from the first surgery, the bony defect thus created, is covered by a piece of bone, which could be autograft, allograft or synthetic material. Till the second surgery, there is always a chance of trauma to the exposed brain in addition to disturbed homeostasis of brain, CSF dynamics and cerebral blood-flow.31,32 In our method, DC is a single-stage surgery. Cranioplasty is done during the first decompressive surgery itself by replacing the bones in small pieces, without compromising the decompressive effect of craniectomy. By around 6 weeks, the brain swelling gradually subsides and acquires an almost slightly curved temporal surface. The bone pieces also fuse by then to attain almost a natural shape of the temporal region. This is demonstrated in postoperative serial CT scans. Thus a second surgery for cranioplasty is avoided along with its other implications including the cost.

Decompressive craniectomy is known to be associated with some common complications. The complications are observed to be greater with low conscious level at presentation, in elderly age group and preoperative use of anticoagulants or antiplatelet agents.42 The known complications of DC are: expansion of pre-existing hemorrhagic contusions, evolution and expansion of contralateral bleed, external cerebral herniation, subdural effusions and hygromas (50%), impaired wound healing, infection, post-DC hydrocephalus (upto 15%), paradoxical herniation, etc.2

Some of these complications were observed in our series too. However, there was no increase in the type or percentage of the complications compared to that mentioned in the literature. There was superficial wound infection in 7 cases (6.7%), which is comparable to the rate of infections mentioned in literature, i.e. 1 to 14.3%.3,15,26 There were no other forms of infections like meningitis or abscess.

Expansion of pre-existing hemorrhagic contusions was observed in 46% of cases but they were managed conservatively. Symptomatic hydrocephalus needing ventriculo-peritoneal shunt, was seen in 11 (10.5%) of our cases, which was comparable to the data published in literature, i.e. 2%–29%.13,36,39,42 Subdual collection is the most common complication (50%) but it was seen in all of our patients.1,12,41 However none of them were symptomatic needing additional treatment. Seizure and congnitive dysfuntions occur due to the primary brain injury and is not related to the procedure.

## Conclusion

Though the role and type of decompressive craniectomy in TBI is not well defined, the surgery is still widely practiced. With a limited FTP craniectomy, decompression can be made equally effective to reduce ICP quickly and adequately in TBI requiring DC. The procedure is cosmetically also more acceptable. The procedure is made more effective by a liberal duroplasty using patient's temporalis fascia and thickened subcutaneous areolar tissue. The surgery can be made a single stage procedure by replacing the bone in small pieces during the primary surgery itself without any added complications and without adversely compromising the decompressive effect of the surgery. This would avoid second surgery for cranioplasty.

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