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Two different surgical techniques for reduction cranioplasty

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Abstract Reduction cranioplasty is required in selected patients when macrocephaly interferes with head control, seating, locomotion, and social acceptance. Two different surgical techniques for reduction cranioplasty in two cases of older hydrocephalic patients are described. Emphasis is placed on the basic stages of the procedure.

Key words Reduction cranioplasty · Surgical technique · Macrocephaly

Introduction

Macrocephaly needing reduction cranioplasty is uncommon. Generally, the neurosurgeon and the family are together capable of preventing this condition, but unfortunately, if the hydrocephalus is neglected by the parents and/or its treatment is ineffective, neurosurgeons are sometimes confronted with this problem. Reduction cranioplasty is required in selected cases of macrocephaly when the size and the weight of the head significantly interferes with normal development or with important activities that would otherwise be possible [1,10–12]. Reduction cranioplasty is also proposed as a treatment modality in the cases of severe craniocerebral disproportion in infancy [7] and in the cases of intractable chronic subdural hematoma in infancy [9].

The paucity of literature about this subject makes it difficult to determine the optimum treatment modality. This report describes two different surgical techniques for reduction cranioplasty and discusses basic stages of this procedure.

Case histories and surgical techniques

Case 1

Clinical history

A 6-year-old boy presented with severe macrocephaly, particularly with a significant increase in vertical height (Fig. 1). Multiloculated hydrocephalus had been diagnosed in utero and he was delivered by elective cesarean section. His head circumference at birth was 54 cm. When he was 2 months of age, a ventriculoperitoneal (VP) shunt was inserted. Despite many revisions, his head circumference increased continuously until he was 4 years old. He was able to talk at 3 years, but walking was impossible.

On examination, the patient's head circumference measured 72 cm. Nasion-inion and bitragal distances were both 70 cm. All calvarial sutures were closed and the bones were thickened. Cognitive development was slightly retarded. The patient was sometimes able to stand with assistance, but his mobility was seriously impaired by the weight of his head.

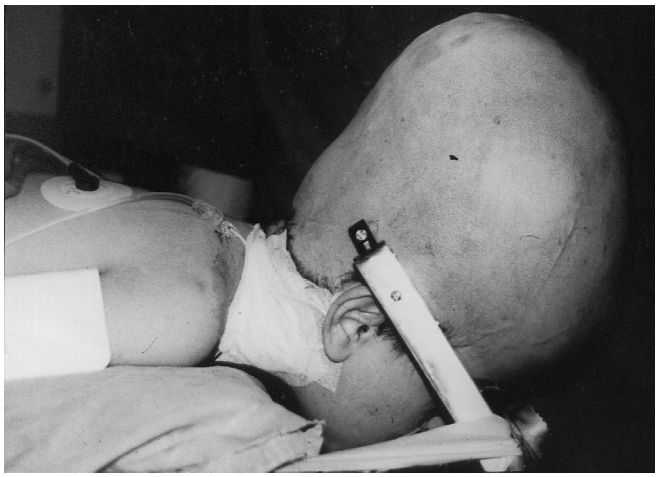

Fig. 1 Operative positioning of the first patient. Note the considerable increase in vertical height of the skull, especially in the posterior parietal area. Adequate exposure of the full cranial vault was possible. Because the bones were extremely thick, three pin fixators could be used in this patient

Surgical technique

The modified prone position [4] with the head in neutral position and slightly extended was easily achieved with three pin fixators and full cranial vault exposure was provided by a bitragal skin incision (Fig. 1). The scalp and periosteum were dissected separately. Aside from three bone strips, one midfrontal and two posterior parietal connecting at the bregma, all calvarial bones were removed and an external drainage was installed (Fig. 2). Under continuous irrigation, the dura was coagulated with a bipolar forceps in many areas, parallel and/or perpendicular to the superior sagittal sinus, in order to attain a reduction in length and in width of the dural envelope. Approximately 2 l cerebrospinal fluid (CSF) was drained during the reduction of the dural envelope. The fragmented bones were then placed in a mosaic fashion and fixed with heavy silk (Fig. 2). External drainage was removed and the remodeled calvarium was entirely covered by intact periosteum. The scalp was closed after resection of the redundant areas.

Postoperative course

One week after the operation, the boy was already able to stand up by himself. Postoperative measurements were 62 cm, 44 cm, and 43 cm for the head circumference, nasion-inion, and bitragal distances respectively. He died 4 months after discharge from the hospital from peritonitis. The cause of this abdominal infection was thought to be related to the shunt, which may have become infected during the reduction cranioplasty.

Case 2

Clinical history

A 5-year-old girl was born with a large head circumference. The macrocephaly was neglected by the parents un-

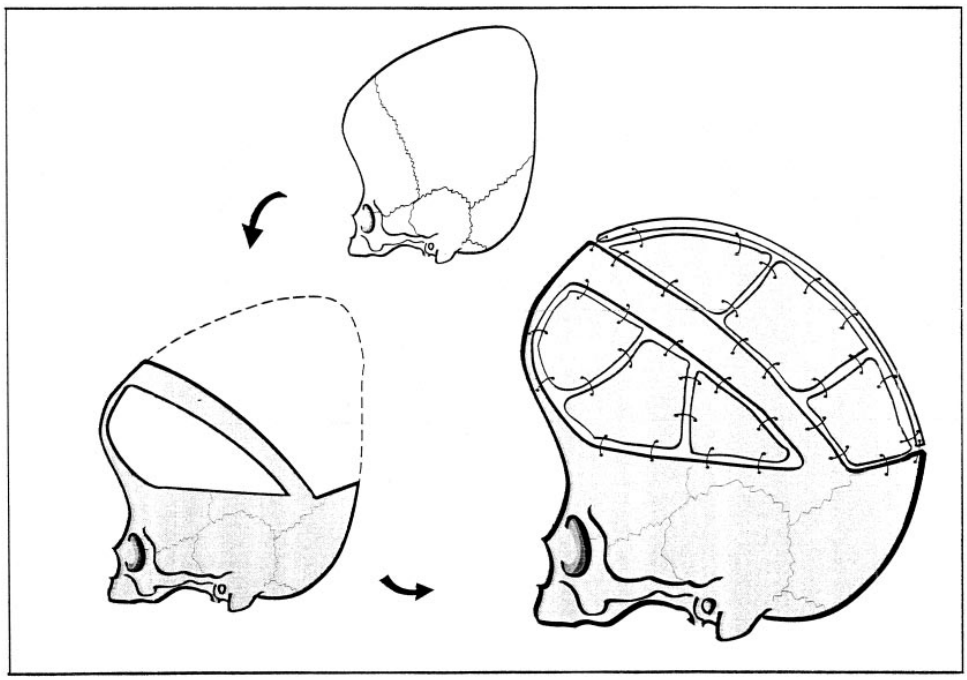

Fig. 2 Modified crossbar technique. The entire calvarium was removed except for a midline strip of frontal bone and two strips of parietal bones laterally. Under controlled drainage of CSF, thermoreduction of the dura was performed. Care was taken not to lacerate or kink the superior sagittal sinus. The posterior part of the sinus was entirely covered by a single fragment of bone in order to avoid any damage to it, and the remaining areas of the calvarium were covered by bone fragments in a mosaic fashion

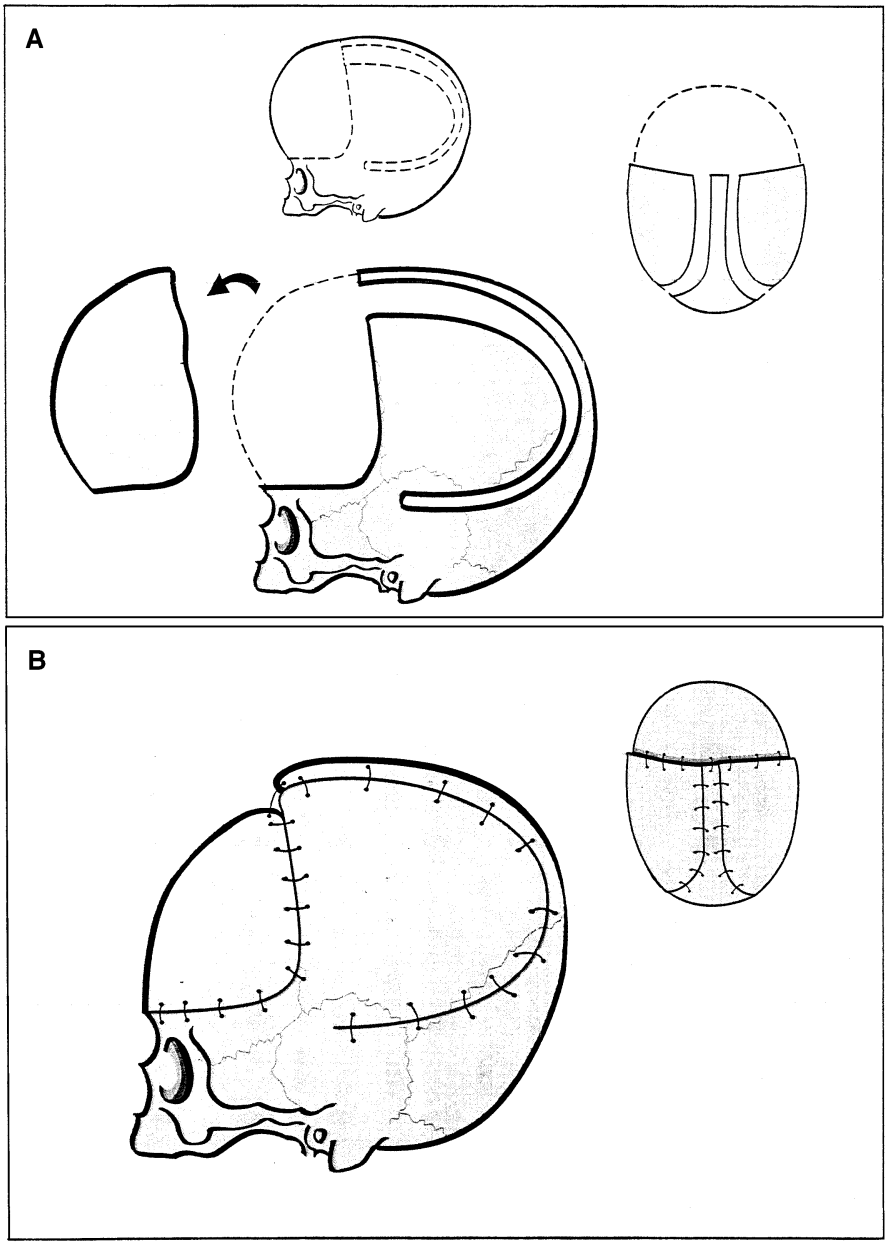

Fig. 3A, B Modified pi craniectomy technique. **A** The frontal bone was removed from just above the orbits. The ends of the parasagittal craniectomies were extended to the temporal squamosa. Thus, two large peninsula-shaped parietal bones were created. The superior sagittal sinus must be completely dissected from the bone to avoid any kinking during reduction. **B** The reduced frontal bone was fixed above the orbits, multiple small drill holes were made along the craniectomy contour, and the bones were adjusted with heavy silk sutures. Under ICP monitoring, the calvarium was compressed and all of the sutures were ligated when the desired reduction was achieved. Note on the axial and sagittal view that an unavoidable transverse dent appeared in the posterior frontal region

til her head circumference reached 60 cm at 2 years of age. A VP shunt was inserted, but the head circumference continued to increase, reaching 74 cm at 5 years of age. The patient underwent shunt revision at 3 years. She began to speak at 4 years.

On examination, the head shape was harmonious except for a prominent frontal boss. The calvarial bones were thin and malleable. The patient could not support the weight of her head without considerable assistance. Nasion-inion and bitragal distances were 71 and 68 cm respectively.

Surgical technique

A neutral prone position with a flexed neck, as in the gel-filled collar technique [2], was used for the operative positioning. After entire exposure of the calvarium, the frontal bone was removed (Fig. 3A). The next part of the surgery was largely inspired by the technical note of Jane et al. regarding scaphocephaly [3]. The ends of the parasagittal craniectomies of the original technique were rotated towards the two temporal squamosa in order to create two large peninsula-shaped parietal bones (Fig. 3A). An external drainage was inserted and linked via a three-way connector to an intracranial pressure

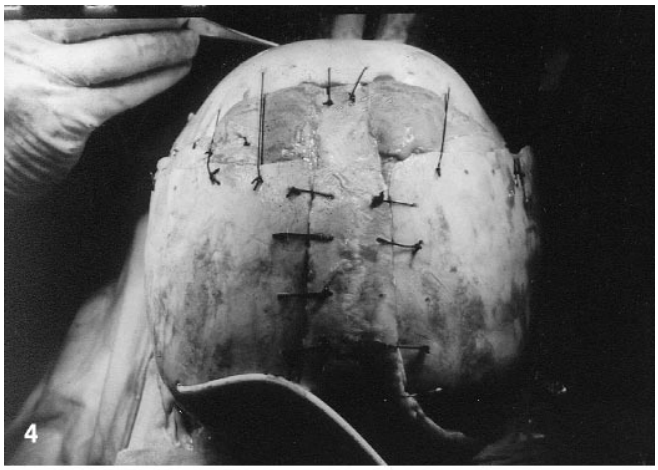

Fig. 4 Operative photograph at the end of the surgery in the second patient. Reduction in width and length was achieved

Fig. 5 Postoperative photograph of the second patient 1 year after surgery. She became able to support the weight of her head easily, but there was serious stepping between the frontal and parietal bones

(ICP) monitor. Initially, l l CSF was aspirated. The ICP levels were between 10 and 12 cm H_2O before the aspiration of CSF, and between 2 and 6 cm H_2O thereafter. Thermoreduction of the dural sac was performed as in case 1.

The bifrontal bone flap was reduced in size and fixed to the supraorbital bar. Then, the calvarium was compressed, while monitoring the ICP. Temporarily, some peaks up to 100 cm H_2O were registered. When the desired reduction in head size had been achieved, the free edges of the bones were ligated (Figs. 3B, 4). During the compression, 1.2 l CSF was discharged from the external drainage. ICP was between 15 and 20 cm H_2O when all bones were covered with intact periosteum. The external drainage was removed and the galea and scalp were closed.

Postoperative course

The patient's postoperative course was uneventful except for a decrease in hematocrit. One month after the operation, she became able to support the weight of her head easily, and 9 months later she was able to stand up with minimal assistance. Measurements were 59 cm, 46 cm, and 42 cm for head circumference, nasion-inion distance, and bitragal distance respectively. There was a cosmetic problem because of stepping between the frontal and parietal bones (Fig. 5).

Discussion

The strategic goal of reduction cranioplasty is to improve the patient's quality of life or to facilitate nursing care; it requires meticulous preoperative planning and a vigorous surgical attack. There is no single ideal technique for reduction cranioplasty because of the differences in the basic characteristics of the patients. These basic characteristics are the skull shape and the thickness and malleability of the calvarial bones.

Surgical technique

The position of the head must enable full cranial vault exposure. The modified prone position, which give access to the entire calvarium [4], was possible with three pin fixators in our first patient, but due to the sutural openings and the malleability of the calvarial bones this position was not suitable for the second patient. Because of the enormous size of the head, every effort should be made to detect air embolization during anesthesia [6].

The surgical technique must be simple and quick to perform. One-stage calvarial reconstruction is preferable to multi-staged operations [5]. The goal of surgery is reduction of the head size in length, width, and height with minimal complications. Cosmetic issues are addressed in a secondary plan. The surgical technique we used in the second case is a simple and easily applicable technique for patients with thin, malleable calvarial bones and permits significant reduction especially in length and width. The picket fence technique previously described by Winston et al. [12] would also have been suitable for this child. We prefered the modified pi craniectomy technique, because we believe that it is simpler than the picket fence technique, and reduction of the anteroposterior diameter is easier than with the picket fence technique. Both techniques give reliable structural stability, and also, as pointed out by Winston et al. [12], continuous support of the calvarial bones prevents sagging of the brain. Cases of vertically expanded calvarium, like our first case, if the bones are malleable, also seem suited

to the picket fence technique, because it permits reduction in height.

When the calvarial bones are thick and are not malleable, reduction cranioplasty is much more difficult. Fragmentation of the cranial vault is necessary and this leads to the problem of stabilization. The quadrantal plate technique described by Winston et al. [12] and the crossbar technique described by Park et al. [5] are appropriate for such cases. The crossbar technique permits a significant reduction in vertical height. In our modified crossbar technique, we entirely fragmented the calvarium posteriorly because it was elongated towards the lambda.

During surgery, bleeding from the large veins in the scalp and from the external surface of the calvarium must be controlled meticulously. Park et al. [5] left the pericranium attached to the bone and cut with bone flaps to minimize blood loss during exposure of the calvarium.

If there is no epidural or subdural dead space, the dural envelope provides a strong inner support for the reconstructed bones. Additionally, intact periosteum gives an external support, if it covers all of the reconstructed bones. Thompson and Hoffman [8] were confronted with collapse of the bone flaps after a reduction cranioplasty and utilized a breast prosthesis to stabilize the flaps.

Reduction of the dural envelope

Reduction of the calvarium implies an appropriate amount of reduction in the size of the dural envelope. We preferred bipolar coagulation to imbrication of the redundant dura. Thermoreduction achieves quick, sufficient, and harmonious reduction in length and width when coagulation is performed at many sites, perpendicular or parallel to the superior sagittal sinus. This technique also has the advantage of not necessitating dural sutures, which may be a source of CSF leakage. Irrigation during coagulation prevents any possible thermal damage to the cortex. We recommend an external ventricular drainage to allow continuous discharge of the CSF and monitoring the ICP. Like other authors, we encountered no problems with venous infarction due to kinking of the superior sagittal sinus or cortical veins. However, any aggressive manipulation in the posterior part of the superior sagittal sinus must be avoided [1, 5].

Management of hydrocephalus

Accumulation of fluid in the subgaleal and epidural space is not uncommon [5, 10, 12]. Resection of the redundant scalp and meticulous repair of dural tears can reduce subgaleal fluid accumulation. Winston et al. [12] reported that a functioning VP shunt in the early postoperative period may reinforce enlarging fluid collection within the potentially gigantic subgaleal–epidural space. They recommend controlling ICP in the early postoperative period by external drainage. Removal of large amounts of CSF during surgery must be avoided in order to allow the dural envelope to maintain close contact with the encompassing bony vault. We agree with Winston et al. [12] about controlling hydrocephalus in the early postoperative period by external ventricular drainage. We did not do it in these two cases because we wanted to give the patients a chance to avoid a further, inevitable VP shunting procedure, but we suggest that preserving shunt material during this major operation carries a high risk of shunt infection, as we found in our first patient.

Cosmetic issues

The reduction of the cranial capacity results largely from changes in the height, length, and width of the calvarium [5]. We must remember that these children with an enormous calvarium have also a considerable increase in skull base diameter which is not reducible, and this fact is the main difficulty of reduction cranioplasty, because the calvarium rests on the skull base. The result is a disproportion of the calvarium–skull base junctions and a poor cosmetic result. We have programmed a second operation in our second patient for retropositioning the cranio-orbital bar and reshaping the forehead. This will allow a reduction in the length of the skull base and a good cosmetic result.

Conclusion

Reduction cranioplasty is a useful neurosurgical operation in selected cases. In many countries, there must be many children with an enlarged cranium needing reduction cranioplasty. All neurosurgeons are familiar with such children, but there is lack of broad clinical experience. We suggest that a treatment protocol should be discussed for these children and the reduction cranioplasty should be considered more often when appropriate.

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References

1. Ehni G (1982) Reduction of head size in advanced hydrocephalus: a case report. Neurosurgery 11:223–228
2. Francel PC, Bell A, Jane JA (1994) Operative positioning for patients undergoing repair of craniosynostosis. Neurosurgery 35:304–306
3. Jane JA, Edgerton MT, Futrell JW (1978) Immediate correction of sagittal synostosis. J Neurosurg 49:705–710
4. Park TS, Haworth CS, Jane JA, Bedford RB, Persing JA (1985) A modified prone position for cranial remodeling procedures in children with craniofacial dysmorphism: a technical note. Neurosurgery 16:212–214
5. Park TS, Grady MS, Persing JA, Delashaw JB (1985) One-stage reduction cranioplasty for macrocephaly associated with advanced hydrocephalus. Neurosurgery 17:506–509
6. Parsons D, Samuels SI, Steinberg G, Shuer L (1988) Reduction cranioplasty and severe hypotension. Anesthesiology 68:145–146
7. Piatt JH, Arguelles JH (1990–91) Reduction cranioplasty for craniocerebral disproportion in infancy: indications and technique. Pediatr Neurosurg 16:265–270
8. Thompson HG, Hoffman HJ (1975) Intracranial use of a breast prosthesis to temporarily stabilize a reduction cranioplasty: case report. Plast Reconstr Surg 55:704–707
9. Tsutsumi K, Asano T, Shigeno T, Matsui T, Ito S, Nakaguti H (1994) Reduction cranioplasty for a case of intractable chronic subdural hematoma in infancy. No Shinkei Geka 22:61–65
10. Ventureyra E, Da Silva VF (1981) Reduction cranioplasty for neglected hydrocephalus. Surg Neurol 15:236–238
11. Vries JK, Habal MB (1979) Craniorbital correction for massive enlargement of the cranial vault. Plast Reconstr Surg 63:446–472
12. Winston KR, Ogilvy CS, McGrail K (1995) Reduction cranioplasty. Pediatr Neurosurg 22:228–234