

Treatment of depressed skull fractures in neonates using percutaneous microscrew elevation

Technical note

OMAR ZALATIMO, M.D., MOKSHA RANASINGHE, M.D., MARK DIAS, M.D.,
AND MARK IANTOSCA, M.D.

Department of Neurosurgery, Penn State Hershey Medical Center, Hershey, Pennsylvania

Depressed skull fractures in neonates involve the inward buckling of the skull bones to resemble a cup shape or “ping-pong ball” shape. In the past, several methods have been used to treat these fractures for cosmetic effect, including the use of vacuum extraction. The aim of this study was to demonstrate the use of a novel treatment method for these skull fractures. All patients presented to Hershey Medical Center between May 2007 and March 2010. All underwent treatment of their ping-pong skull fracture using a novel technique of percutaneous screw elevation with self-tapping microscrews (4 or 5 mm) typically used in neurosurgery for cranial plating. Four patients were treated, all between the ages of 2 days and 4 months. Two of the patients were treated under general anesthesia and 2 with local anesthesia only. All patients had good cosmetic results and experienced no adverse events. Percutaneous screw elevation of the ping-pong type, simple depressed skull fracture in neonates is a feasible method of treatment with a low complication rate associated with the procedure and no risk from anesthesia.
(<http://thejns.org/doi/abs/10.3171/2012.2.PEDS11304>)

KEY WORDS • depressed skull fracture • percutaneous • elevation •
microscrew • trauma

DEPRESSED skull fractures that occur in children younger than 1 year are different from those that occur in older children or adults. The lack of ossification of the neonatal skull gives it a relative plasticity. A depressed skull fracture in these neonates forms an inward buckling of the calvarial bones into a cup shape, termed a “ping-pong ball” or “pond” fracture. Skull fractures occur at any age after direct impact on the bone by an object, but simple depressed skull fractures are observed in neonates with less significant trauma.²⁹

Simple depressed skull fractures have been well recognized in the neonate period^{1–3,5,8–12,19,22,27,29–31,33} and beyond. Congenital depressions of the skull have an incidence of 1 in 10,000 births. These are believed to occur secondary to the pressure of fingers or wrists of the neonate over the surface of the cranium in utero.¹³ Acquired depressed skull fractures are generally due to obstetrical maneuvers during difficult deliveries and due to head trauma.^{9,25}

In the neonate, ping-pong ball or pond fractures occur with indentation of the bone surface without disruption of the continuity of the bone (similar to green stick fractures of the long bones).²¹ Typically the outer

table is fractured around the periphery, while the inner table fractures at the center. The neurological sequelae of hemorrhage and dural lacerations noted in compound depressed skull fractures are not normally observed with simple depressed skull fractures.^{7,14–16,18,24,29,32} It has been demonstrated previously that the natural history of these depressed skull fractures is variable, with some elevating spontaneously over time and others remaining depressed.²⁹ But there is a great deal of parental anxiety regarding such fractures due to the cosmetic effect of the lesion, which tends to govern its management.

The management of these fractures has been controversial. These fractures have traditionally been managed surgically.^{4,21} More recently there have been demonstrations of spontaneous elevation,^{6,10,17,19,23,26} although there are no definite predictors to demonstrate which fractures elevate spontaneously. It has been demonstrated that the deeper the depressed bone (> 1 cm), the higher the risk of dural laceration and cortical laceration in adults and older

This article contains some figures that are displayed in color online but in black-and-white in the print edition.

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children.¹⁰ These critical dimensions are less well known for the neonate and infant populations. Several nonsurgical elevation techniques that use the fact that the bone is in partial continuity have been demonstrated; these techniques include elevation using digital pressure,²⁵ and vacuum devices such as a breast pump²⁸ and a vacuum extractor.^{8,20,27,30,31,33}

The direct operative techniques carry the disadvantages of prolonged hospital stay and risks of open surgery. Vacuum devices that have been demonstrated carry the disadvantages of patient discomfort, inability to obtain complete correction of the depression, and creation of local cephalohematoma with the procedure. The use of these devices also demonstrates a physician learning curve for mastery of the procedure.^{17,30}

An ideal method for treatment of deep depressed skull fractures would consider patient safety, would have the ability to correct the deformity immediately, would be time and cost effective, and would use instruments and techniques that are familiar to the neurosurgeon. In this report, we demonstrate successful elevation of simple depressed skull fractures in 4 neonates using percutaneous screw elevation with self-tapping microscrews used for cranial plating in neurosurgery. This method has proven to be low risk and highly effective.

Methods

We report a novel technique applied to neonates admitted to the Penn State Children's Hospital between May 2007 and March 2010. Four male neonates who presented between 2 days and 4 months of age were treated. All patients had a traumatic history postpartum except for 1 who was delivered by cesarean section following multiple attempts at forceps-assisted delivery. All of the children were of normal weight and born full term with normal neurological examination results. The characteristics of the 4 patients in the study are shown in Table 1. The 2-day-old child was transferred from another facility and was found to have had no spontaneous elevation of the depressed skull fracture at 48 hours. In all patients the depressed skull fracture was in a parietal location.

All patients underwent hematological and coagulation studies prior to the procedure. The procedure was then explained in detail to the parents and informed consent was obtained. Preoperative CT scans showed no hemorrhage, sinus involvement, or other underlying lesions. All patients had skull depressions > 2 cm in the

greatest depth and > 4 cm in length/diameter. Within 72 hours of the injury, all skull fractures were elevated to normal anatomical alignment, symmetrical to the contralateral side.

The initial 2 cases were performed under general anesthesia to ease the ability of the surgeon to proceed with open elevation in the event that percutaneous elevation was not successful. After completion of 2 cases under general anesthesia, with greater confidence in the procedure subsequent surgeries were performed with only local anesthesia to the site of the intended screw application. This procedure was performed in the neonatal intensive care unit and the pediatric intermediate care unit at the patient's bedside. The objective of the study was to demonstrate the validity of a technique that could be performed with minimal risk of general anesthesia and open surgery.

Operative Technique

A self-tapping screw (3–5 mm long) from the Synthes low-profile cranial plating system was used for the procedure. Preoperative CT scans showed no intracranial injury associated with the fracture and demonstrated a depression > 2 cm in all cases.

The region of the depression was prepared to the periphery in all cases (Fig. 1A). The region adjacent to the point of greatest depression was located and infiltrated with 1% lidocaine. In the first 2 cases, small stab incisions were made to the bone using a no. 11 scalpel prior to placing a 3- or 4-mm self-tapping screw, just deep enough to anchor to the bone but not completely sink into the skull. In the final 2 cases, 4- or 5-mm screws were placed percutaneously until the screw was believed to be through the bone (Fig. 1B).

While the child's head was held in position by an as-

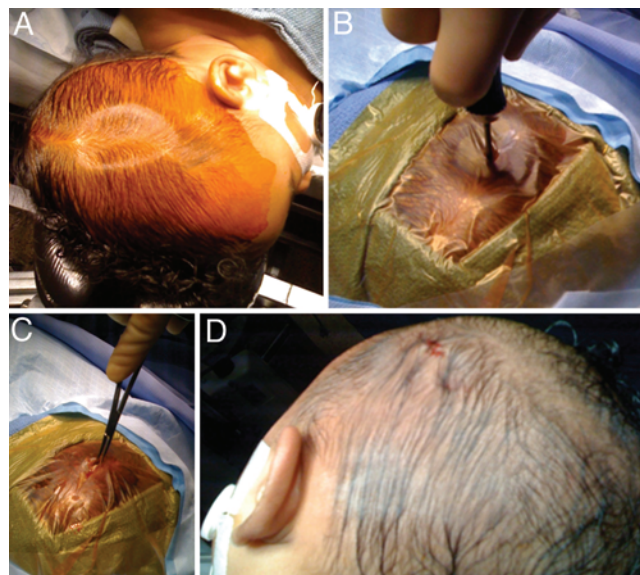


FIG. 1. Photographs of the procedure in Case 2. **A:** Prepared surface of the depressed skull fracture. **B:** Placement of the self-tapping screw. **C:** Elevation of the screw with the use of a Kelly clamp. **D:** Complete cosmetic result after the procedure.

TABLE 1: Characteristics of the patients in the study*

Case No.	Age	Mechanism of Injury	Anesthesia	Follow-Up
1	2 mos	fall down stairs	general & local	1.5 yrs
2	4 mos	fall from sibling arms	general & local	6 mos
3	3 mos	fall off kitchen counter	local only	1 yr
4	2 days	traumatic delivery	local only	1 mo

* Operating duration was < 5 minutes in all patients, all patients were boys, and all were discharged on postoperative Day 1.

sistant, traction opposite the depression was then applied after a Kelly clamp was placed on the screw head, until elevation of the fracture was successful (Fig. 1C). Linear gentle traction on the screw with the Kelly clamp perpendicular to the fracture is essential for success. In 1 instance, when the screw was not through the bone (or likely barely through the outer table), it pulled out but was easily replaced in the same hole and advanced a little further. Upon successful elevation, an audible “pop” occurs, which is also heard in the open surgical elevation technique. Visually the elevation is very apparent when it occurs because there is a low risk of a local hematoma. In Cases 1 and 2, a suture was placed at the site of the scalpel stab wound. In Cases 3 and 4, no suture was necessary. All wounds were dressed with bacitracin ointment.

All cases showed immediate complete cosmetic elevation of the fracture (Fig. 1D). Three of the patients received postoperative CT scans, and 1 patient had skull radiographs, all showing complete elevation of the fracture. Preoperative and postoperative CT scans are shown for Case 2 in Fig. 2. The CT scans did not show any pneumocephalus, hemorrhage, or other intracranial abnormality.

After observation overnight, all patients were discharged on postoperative Day 1. Routine clinical follow-up consisting of a general examination, head circumference measurements, and a psychomotor evaluation was performed 2 weeks after the procedure and at 3-month intervals up to 1.5 years following the procedure.

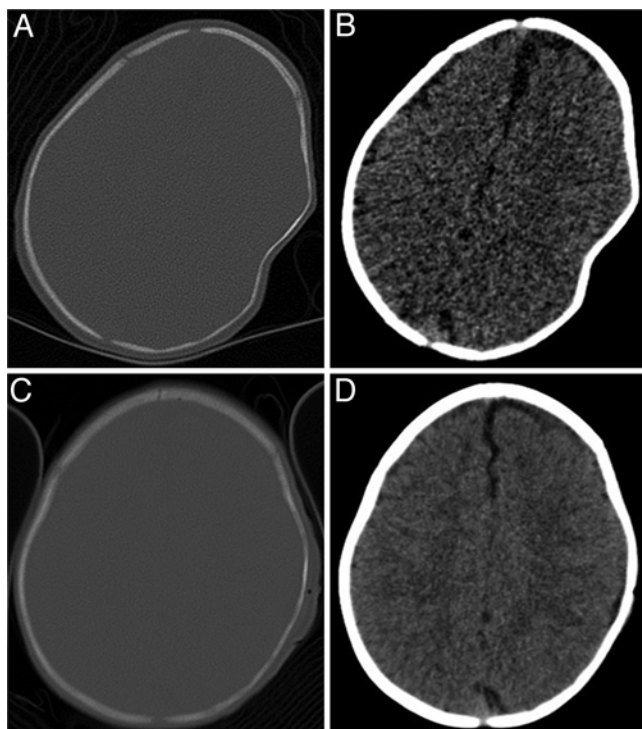


Fig. 2. Preoperative and postoperative axial CT scans in Case 2 showing complete resolution of the depressed skull fracture. **A:** Preoperative scan with bone windows showing a deep left parietal skull fracture. **B:** Preoperative scan with brain windows. **C:** Postoperative scan with bone windows showing complete correction of depressed skull fracture. **D:** Postoperative scan with brain windows.

Discussion

Using the novel microscrew method demonstrated in this study made it possible to achieve a complete curative cosmetic result in all 4 patients treated. This technique was safe, effective, and required only a brief operative time.

There were no immediate postoperative complications as assessed by postoperative examinations and CT scans. In the follow-up period up to 18 months, the patients experienced no recurrence of the depressive deformity and experienced good progression of their psychomotor development as expected for their age. In comparison with other reported methods, there is also a low risk of local hematoma (which may lead to hematological complications) or patient discomfort using this method, which are the major risks of open surgery and other minimally invasive treatment approaches with suction devices. It must be noted that if care is not taken to ensure that the microscrew is placed carefully so that it just anchors to the skull, there may be a risk of dural laceration. This risk would be expected to be low because neonatal dura is less adherent to the skull and because the site of entry is adjacent to the site of the fracture, which prevents the surgeon from “plunging in” at the fracture site. There is minimal risk of infection, and the scar formed is minimal and rarely noticeable at follow-up. We believe that this procedure has an overall low risk for the neonate, but our study was limited to 4 patients; thus a larger study may be required to investigate all possible risks.

We also demonstrated that the procedure could be performed with ease at the bedside with only local anesthetic. This option avoids subjecting neonates to surgical intervention under general anesthesia with risks of bleeding, hypothermia, and anesthetic complications. The instruments used in this procedure are very familiar to neurosurgeons and are used in many other procedures, thereby minimizing a surgeon’s learning curve for the procedure. Until a larger study is available that evaluates the complete risks of the procedure, basic life monitoring (heart rate, pulse oximetry, and blood pressure) is recommended for this procedure, followed by inpatient observation overnight. Therefore, at this time we do not recommend that this procedure be performed on an outpatient basis.

Conclusions

We believe that the novel technique demonstrated in this paper is simple, inexpensive, and as effective as the other demonstrated procedures available for treatment of ping-pong ball fractures. The procedure can be performed under local anesthesia, avoiding the risk of a surgical intervention. This technique also allows for a shorter hospital stay than an open surgical technique. It carries the added advantage of utilizing instruments familiar to the neurosurgeon, minimizing the learning curve for the procedure.

Disclosure

The authors report no conflict of interest concerning the mate-

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rials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Zalatimo, Ranasinghe, Iantosca. Acquisition of data: Zalatimo, Ranasinghe. Analysis and interpretation of data: Zalatimo, Ranasinghe, Dias. Drafting the article: Zalatimo, Ranasinghe. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Zalatimo. Study supervision: Ranasinghe, Dias, Iantosca.

References

1. Apoas AR: Skull fractures, in Palmer JD (ed): **Manual of Neurosurgery**, ed 5. Edinburgh: Churchill Livingstone, 1996, pp 516–517
2. Ben-Ari Y, Merlob P, Hirsch M, Reisner SH: Congenital depression of the neonatal skull. **Eur J Obstet Gynecol Reprod Biol** 22:249–255, 1986
3. Beyers N, Moosa A, Bryce RL, Kent A: Depressed skull fracture in the newborn. A report of 3 cases. **S Afr Med J** 54:830–832, 1978
4. Bullock MR, Chesnut R, Ghajar J, Gordon D, Hartl R, Newell DW, et al: Surgical management of depressed cranial fractures. **Neurosurgery** 58 (3 Suppl):S52–S56, Si–Siv, 2006
5. Camus M, Lefebvre G, Veron P, Darbois Y: [Obstetrical injuries of the newborn infant. Retrospective study apropos of 20,409 births.] **J Gynecol Obstet Biol Reprod (Paris)** 14: 1033–1043, 1985 (Fr)
6. Cozzens JW, Eller TW: Spontaneous reduction of a closed depressed skull fracture: a case report. **Neurosurgery** 20:771–773, 1987
7. Curry DJ, Frim DM: Delayed repair of open depressed skull fracture. **Pediatr Neurosurg** 31:294–297, 1999
8. de Paul Djientcheu V, Njamnshi AK, Ongolo-Zogo P, Ako S, Essomba A, Sosso MA: Depressed skull fractures in children: treatment using an obstetrical vacuum extractor. **Pediatr Neurosurg** 42:273–276, 2006
9. Dupuis O, Silveira R, Dupont C, Mottolise C, Kahn P, Dittmar A, et al: Comparison of “instrument-associated” and “spontaneous” obstetric depressed skull fractures in a cohort of 68 neonates. **Am J Obstet Gynecol** 192:165–170, 2005
10. Erşahin Y, Mutluer S, Mirzai H, Palali I: Pediatric depressed skull fractures: analysis of 530 cases. **Childs Nerv Syst** 12: 323–331, 1996
11. Garza-Mercado R: Intrauterine depressed skull fractures of the newborn. **Neurosurgery** 10:694–697, 1982
12. Greenberg MS: **Handbook of Neurosurgery**, ed 5. New York: Thieme, 2001, pp 655–656
13. Guha-Ray DK: Intrauterine spontaneous depression of fetal skull: a case report and review of literature. **J Reprod Med** 16:321–324, 1976
14. Hall JR, Reyes HM, Horvat M, Meller JL, Stein R: The mortality of childhood falls. **J Trauma** 29:1273–1275, 1989
15. Heary RF, Hunt CD, Krieger AJ, Schulder M, Vaid C: Non-surgical treatment of compound depressed skull fractures. **J Trauma** 35:441–447, 1993
16. Humphreys RP: Complications of pediatric head injury. **Pediatr Neurosurg** 17:274–278, 1991–1992
17. Hung KL, Liao HT, Huang JS: Rational management of simple depressed skull fractures in infants. **J Neurosurg** 103 (1 Suppl):69–72, 2005
18. Jennet B: **Epilepsy After Non-Missile Head Injuries**, ed 2. London: William Heinemann, 1975
19. Loeser JD, Kilburn HL, Jolley T: Management of depressed skull fracture in the newborn. **J Neurosurg** 44:62–64, 1976
20. Mastrapa TL, Fernandez LA, Alvarez MD, Storrs BB, Flores-Urueta A: Depressed skull fracture in Ping Pong: elevation with Medeva extractor. **Childs Nerv Syst** 23:787–790, 2007
21. Matson DD, Ingraham FD (eds): **Neurosurgery of Infancy and Childhood**, ed 2. Springfield, IL: Charles C Thomas, 1969, p 934
22. Nakahara T, Sakoda K, Uozumi T, Takeda T, Ogorochi T, Ueda K, et al: Intrauterine depressed skull fracture. A report of two cases. **Pediatr Neurosci** 15:121–124, 1989
23. Natelson SE, Sayers MP: The fate of children sustaining severe head trauma during birth. **Pediatrics** 51:169–174, 1973
24. Nimityongskul P, Anderson LD: The likelihood of injuries when children fall out of bed. **J Pediatr Orthop** 7:184–186, 1987
25. Raynor R, Parsa M: Nonsurgical elevation of depressed skull fracture in an infant. **J Pediatr** 72:262–264, 1968
26. Ross G: Spontaneous elevation of a depressed skull fracture in an infant. Case report. **J Neurosurg** 42:726–727, 1975
27. Saunders BS, Lazoritz S, McArtor RD, Marshall P, Bason WM: Depressed skull fracture in the neonate. Report of three cases. **J Neurosurg** 50:512–514, 1979
28. Schragger GO: Elevation of depressed skull fracture with a breast pump. **J Pediatr** 77:300–301, 1970
29. Steinbok P, Flodmark O, Martens D, Germann ET: Management of simple depressed skull fractures in children. **J Neurosurg** 66:506–510, 1987
30. Tannirandorn Y, Thaithumyanon P, Aroonrasmeruang T: Elevation of depressed skull fracture in the neonate by obstetrical vacuum extractor. **J Med Assoc Thai** 76:698–702, 1993
31. Tysvaer A, Nysted A: [Depression fractures of the skull in newborn infants. Treatment with vacuum extractor.] **Tidsskr Nor Laegeforen** 114:3315–3316, 1994 (Norwegian)
32. Williams RA: Injuries in infants and small children resulting from witnessed and corroborated free falls. **J Trauma** 31:1350–1352, 1991
33. Wu CM, Hung KL, Chen TH: [A case report of depressed skull fracture of the newborn treated with a vacuum extractor.] **Taiwan Yi Xue Hui Za Zhi** 84:270–275, 1985 (Chinese)

Manuscript submitted July 18, 2011.

Accepted February 16, 2012.

Portions of this work were presented in January 2009 at the 31st Annual Meeting of the American Society of Pediatric Neurosurgeons in Kohala Coast, Hawaii, and in July 2010 in poster format at the 97th Annual Meeting of the Pennsylvania Neurosurgical Society in Hershey, Pennsylvania.

Please include this information when citing this paper: DOI: 10.3171/2012.2.PEDS11304.

Address correspondence to: Omar Zalatimo, M.D., Department of Neurosurgery, Penn State Hershey Medical Center, 30 Hope Drive, C 110, Hershey, Pennsylvania 17033. email: ozz101@gmail.com.