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.

Simple depressed skull fractures have been well recognized in the neonate period 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. Acquired depressed skull fractures are generally due to obstetrical maneuvers during difficult deliveries and due to head trauma.

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). 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. 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. 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. More recently there have been demonstrations of spontaneous elevation, 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 patients.

key WOrds • depressed skull fracture • percutaneous • elevation • microscrew • trauma
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children. 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.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.17,20

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 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-

TABLE 1: Characteristics of the patients in the study*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age</th>
<th>Mechanism of Injury</th>
<th>Anesthesia</th>
<th>Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 mos</td>
<td>fall down stairs</td>
<td>general &amp; local</td>
<td>1.5 yrs</td>
</tr>
<tr>
<td>2</td>
<td>4 mos</td>
<td>fall from sibling arms</td>
<td>general &amp; local</td>
<td>6 mos</td>
</tr>
<tr>
<td>3</td>
<td>3 mos</td>
<td>fall off kitchen counter</td>
<td>local only</td>
<td>1 yr</td>
</tr>
<tr>
<td>4</td>
<td>2 days</td>
<td>traumatic delivery</td>
<td>local only</td>
<td>1 mo</td>
</tr>
</tbody>
</table>

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

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.
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 scalp 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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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.

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