Korean J Neurotrauma. 2023 Dec;19(4):471-479
https://doi.org/10.13004/kjnt.2023.19.e39
pISSN 2234-8999·eISSN 2288-2243

KJNT

Case Report

Check for updates

Epidural Hematoma, a Rare Complication After the Use of Mayfield Clamp: A Case Report and Review of the Literature

Martin Plevko [1,2], **Václav Vybíhal** [1,2], **Marek Sova** [1,2], **Pavel Fadrus** [1,2], and **Martin Smrčka** [1,2]

[1]Department of Neurosurgery, Faculty of Medicine, Masaryk University, Brno, Czech Republic
[2]Department of Neurosurgery, University Hospital Brno, Brno, Czech Republic

OPEN ACCESS

Received: Jun 15, 2023
Revised: Aug 23, 2023
Accepted: Aug 29, 2023
Published online: Sep 7, 2023

Address for correspondence:
Václav Vybíhal
Department of Neurosurgery, Masaryk University, University Hospital Brno, Jihlavská 20, CZ - 625 00 Brno, Czech Republic.
Email: vybihal.vaclav@fnbrno.cz

ORCID iDs
Martin Plevko
https://orcid.org/0000-0002-9174-7788
Václav Vybíhal
https://orcid.org/0000-0002-5154-5591
Marek Sova
https://orcid.org/0000-0001-7382-9811
Pavel Fadrus
https://orcid.org/0000-0003-3259-1100
Martin Smrčka
https://orcid.org/0000-0002-9191-8700

Conflict of Interest
The authors have no financial conflicts of interest.

Availability of Data and Materials
Not applicable.

ABSTRACT

Herein, we describe a case of epidural hematoma associated with the use of a Mayfield head clamp. An 18-year old patient with an upper brainstem tumour causing obstructive hydrocephalus underwent a routine third ventriculostomy, which unexpectedly revealed an intracranial hemorrhage. We outline potential risk factors, propose an algorithm for preventing complications associated with the use of pin-type fixation, and conducted a structured review of the literature to identify similar clinical scenarios.

Keywords: Cranial epidural hematoma; Complication; Hydrocephalus

INTRODUCTION

Head-immobilization devices (HIDs) play a pivotal role in neurosurgical practice, with the Mayfield clamp and Sugita clamp being among the commonly used types. The Mayfield skull clamp, recognized for its ease of operation, stands out as the most frequently employed rigid head fixation device. Despite its widespread use and generally accepted safety, it has been associated with various complications, many of which may be potentially life-threatening.[2] Intracranial hemorrhage is the most commonly reported complication associated with the use of HID, with this case report focusing on epidural hematoma (EDH) directly attributed to the application of the Mayfield clamp.

We conducted a comprehensive literature search using the PubMed database to identify original articles published between 1980 and 2021. The search terms "epidural hematoma AND clamp/pin" were employed to retrieve relevant studies. Eligibility criteria included articles with an English abstract and complications clearly attributed to the Mayfield skull clamp. We identified the clinical backgrounds of the presented cases, types of procedures performed, possible causes, and outcomes (TABLE 1).

TABLE 1. Review of case reports presenting Mayfield clamp related EDH in various clinical situations

References	Case description	Probable cause	Diagnosis, treatment, outcome
Baerts et al.[1] (1984)	10yo girl Right F-T glioma 10th day postop headaches, vomiting	Age Inadequate reduction of holding pressure according to age Inappropriate pin type	Evacuation of EDH from small craniotomy. Without neurological deficit.
Furuya et al.[6] (2021)	67yo male Chronic kidney disease with need of periodic dialysis Cervical spondylothic myelopathy with aim to perform laminoplasty	Renal osteopathy	Emergent intraop. CT scan of the head. Conservative treatment of epidural haematoma. Laminoplasty performed on next day without rigid head fixation. No neurol. deficit.
Yan[27] (2007)	15yo boy Posterior fossa tumour Hydrocephalus	Age Hydrocephalus (chronic raise of ICP)	Emergent CT scan of the head. Outcome/treatment not known.
Lee and Lin[14] (2010)	38yo woman Posterior spinal C4-6 instrumented fusion Headache and nauzea 1st and 2nd postop. day.	Position of the pins in areas of physiological thinning (Temporal squama)	CT scan of the head 2nd postop. day. Emergent left temporal craniotomy and evacuation of the haematoma. Need for surgical revision of craniotomy site 8 days later for CSF leak and pneumocephalus. No neurological deficit afterwards.
Naik et al.[17] (2011)	40yo woman Right vestibular schwannoma Communication hydrocephalus (shunted)	Hydrocephalus (Chronic raise of ICP) Loss of tamponade effect during surgery	Cerebellar parenchyma seemed to be unusually tense intraop., therefore postop CT scan performed. Bilateral EDH evacuation from craniotomies. Without new neurological deficit.
Parenrengi et al.[18] (2019)	11yo girl Posterior fossa tumour Non-communicating hydrocephalus	Age Hydrocephalus (chronic raise of ICP)	Former surgery stopped. Intraop. emergent CT scan of the head. Evacuation of right sided epidural haematoma. Surgical removal of post. fossa tumour on 5th post op day. No neurol. deficit.
Krishnan et al.[13] (2016)	12yo girl Cystic tumour of 4th ventricle Hydrocephalus- preop. Introduction of EVD	Age Hydrocephalus (chronic raise of ICP) Pin positioning Reduction of tamponade effect by intraoperative CSF drainage	Unusual intraop. bulging of cerebellar parenchyma through craniotomy after resection of the tumour.C1 and C2 laminotomy. "Blown pupils" after op. Emergent CT scan and evacuation of EDH. Outcome: prolonged intubation, tracheostomy, shunt dependence, posterior fossa pseudomeningocoele residual ataxia, and cerebellar signs.
Jha et al.[11] (2009)	22yo male 4th ventricle tumour Obstructive hydrocephalus	Chronic hydrocephalus (thinning of the cranium due to chron. Raised ICP)	Bulging of cerebellar parenchyma intraop. Emergent CT and evacuation. Slow recovery, without permanent deficit.
Bindra et al.[3] (2012)	40yo woman Right acoustic schwannoma	Reduction of tamponade effect. Pin positioning Prolonged fixation	Intraop. bulging of the parenchyma refractory to antioedematous therapy. Immediate postop CT scan reveals bilat. EDH. EDH evacuated immediately from burr holes. No neurologic deficit.
Vitali and Steinbok[25] (2008)	5 paediatric cases- age 2–7 years Posterior fossa tumours Hydrocephalus	Age Thinning of the cranium due to chronic hydrocephalus and raised ICP Pin positioning Use of adult pins Grasp pressure	Intraop. or postop CT scan of the head. Evacuation of EDH either by craniotomy, burr hole, or conservative treatment. One case with residual light right-sided hemiparesis.
Tyagi et al.[24] (2019)	22yo male Fourth ventricular outlet obstruction C1 laminotomy and midline suboccipital craniotomy	Chronic hydrocephalus Pin positioning	8H postop. deterioration of consciousness. Acute CT scan reveals large numerous epidural haematomas. Need for 2 surgical revisions. Outcome: pseudomeningocoele, wound side CSF leak, thecoperitoneal shunt dependence, no motor deficit.
Sade and Mohr[20] (2015)	24yo male Fronto-parietal, Parasagittal meningioma with large surrounding oedema	Chronic raise of ICP Pin positioning	6H post op deterioration of consciousness, right-s. hemiparesis. Acute CT scan of the head. Evacuation of EDH from craniotomy. No neurologic deficit.
Serramito-García et al.[21] (2009)	19yo male Endoscopic third ventriculostomy Obstructive hydrocephalus	Hydrocephalus	Not known.
Erbayraktar et al.[4] (2001)	23yo male Frontal craniectomy	Excessive grasp pressure. Defective part of the spring laden pin	Emergency CT scan reveals intracranial penetrating injury with epidural haematoma. Evacuation of haematoma from craniotomy. Favourable outcome.

(continued to the next page)

https://doi.org/10.13004/kjnt.2023.19.e39

TABLE 1. (Continued) Review of case reports presenting Mayfield clamp related EDH in various clinical situations

References	Case description	Probable cause	Diagnosis, treatment, outcome
Matouk et al.[16] (2012)	79yo male, Chronic renal failure-dialysis dependent Epilepsy on medication Posterior cervical decompression	Position of pins Renal osteodystrophy Multiple AEDs	Unusual nesting of single pin when adjusting holding pressure. Removing the clamp and immediate CT scan. Conservative treatment.

Case description summarises background of each of the cases. Probable cause suggests most important factors that might have played a role in EDH formation. Diagnosis, treatment and outcome describes aftermath of each of the cases.[1,3,4,6,11,13,14,16-18,20,21,24-26]

EDH: epidural hematoma, yo: year old, CT: computed tomography, ICP: intracranial pressure, CSF: cerebrospinal fluid, EVD: external ventricular drainage, AED: antiepileptic drugs.

CASE REPORT

An 18-year-old male presented to our department with a one month history of headaches, fatigue, and remittent episodes of nausea, primarily in the morning. There was no recent history of head trauma or specific drugs use. Upon physical examination, we observed an additional upward gaze palsy that was more pronounced in the left eye. Computed tomography (CT) and brain magnetic resonance imaging were performed (**FIGURE 1**), which revealed a lesion indicative of a high-grade tumor. This tumor was found to obstruct the Sylvian aqueduct, leading to obstructive hydrocephalus. We initially introduced external ventricular drainage from the right side to temporarily relieve obstructive hydrocephalus. Subsequently, to definitively treat the hydrocephalus and identify the tumor type, we conducted an endoscopic biopsy and third ventriculostomy. During the procedure, the patient's head was securely fixed with a three-point Mayfield skull clamp, utilizing Kocher's point on the left side. No adverse events occurred during the procedure. The patient regained full consciousness and was stable without any new neurological deficits. However, the following day, the patient complained of an increased headache. Although the surgical wound appeared to be healing well, edema developed in the right temporal region, precisely at the site where a single fixation pin had been placed. A CT scan of the head was performed (**FIGURE 2**), revealing an unexpected EDH in the right temporal region, along with thinning of the temporal squama in the bone window (**FIGURE 3**). To address this, we performed an acute right-sided temporal craniotomy with hematoma evacuation and hemostasis of the bleeding branch of the middle meningeal artery. The patient's clinical course

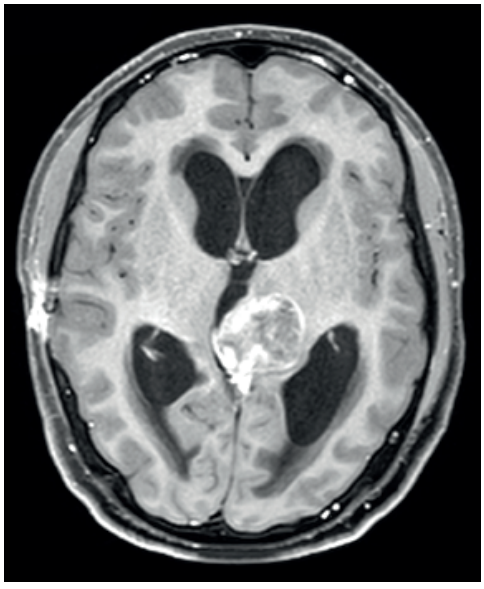

FIGURE 1. Non-homogenically enhancing lesion of upper brainstem, causing obstructive hydrocephalus.

https://doi.org/10.13004/kjnt.2023.19.e39

FIGURE 2. An epidural, supratentorial collection of blood with significant mass effect. External ventricular drainage placed in left ventricle.

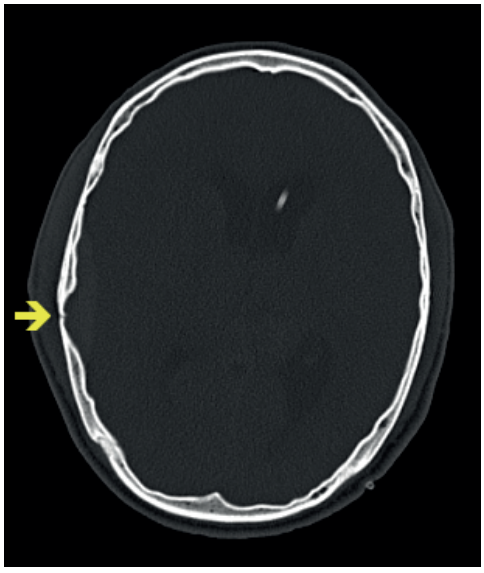

FIGURE 3. Bone window of the skull after endoscopic third ventriculostomy procedure. The yellow arrow is a small fracture of temporal squama. Notice the thickness of the bones of skull.

was uneventful and he was discharged five days later. Unfortunately, subsequent pathological analysis of the tumor confirmed it to be a glioblastoma multiforme with unfavorable genotypic characteristics, resulting in a poor prognosis. Consequently, the patient underwent further oncological treatment.

DISCUSSION

The Mayfield skull clamp, developed by Mayfield and Kees in 1973, is a well-established HID widely used in neurosurgical practice. It employs three pins and offers the advantage of adjustable contact pressure, making it a preferred choice for rigid head fixation. While

https://doi.org/10.13004/kjnt.2023.19.e39

neurosurgeons use these devices routinely, concrete guidelines for their use and management of associated complications are lacking in the literature. Nevertheless, there are general principles, that must be adhered to during placement to ensure stability and safety, and several comprehensive reviews have attempted to summarize these principles.[2,23]

Rare complications include venous air embolism[12,19] clamp breakage,[22] arteriovenous fistula formation,[8] temporal aneurysm formation,[5] temporal facial nerve branch palsy[15] and others. Among these, fractures of the skull with or without intracranial hemorrhage are the most frequently reported complications.[2,23] A recent single-center retrospective study by Hiwatari et al.[7] found the incidence of this complication to be approximately 0.29% in adults. However, this figure may be somewhat inaccurate, as this study exclusively examined cases associated with the Sugita head frame. Conversely, according to another study by Vitali and Steinbok,[25] the incidence of complications related to Mayfield fixation was more than doubled among pediatric patients (0.65%). We identified 15 separate case reports that included 19 patients diagnosed with EDH attributable to the use of the Mayfield head clamp (**TABLE 1**). Patients' ages ranged from 2 to 79 years (median, 19 years).

We identified several risk factors that may play a significant role in adult and pediatric populations.

1) Age: Numerous case reports have included pediatric patients, which is unsurprising. Young individuals often have thinner and less calcified bones, rendering less resistant to pin pressure.[23,25]

2) Type of HID used: While the exact incidence related to different types in adult populations is unknown due to a lack of studies, Hiwatari's paper[7] suggests that Mayfield fixation may be a safer choice based on their findings, which exclusively linked EDH to the Sugita system.

3) Chronic increase in intracranial pressure (ICP): typically occurs in patients with hydrocephalus. As shown in **TABLE 1**, nine of 15 papers documented hydrocephalus or other elevated ICP.[11,13,17,18,20,21,24-26] Chronic elevation of ICP appears to lead to calvarial bone thinning, increasing fragility.

4) Chronic disease/medication: There are two case reports that mentioned intracranial hemorrhage in patients with chronic renal disease requiring regular dialysis.[6,16] Other cases were connected to use of certain antiepileptic medications.[10,16] However, owing to the limited quality of data, it remains uncertain whether these factors play a significant role.

5) Pin positioning: Correct pin placement is crucial to ensure both stability and safety. Two major factors must be carefully titrated to ensure correct fixation. This ensures the stability and safety of grasping. Typically, overt stability leads to greater damage, and vice versa. Certain points should always be assessed when applying a clamp to the head:

- Inspect the Clamp: Always check the clamp for damage before use. A single case report mentioned clamp breakage during a procedure, fortunately causing no additional harm to the patient.[22]

- Select a Safe Zone: Avoid naturally thinner zones of bones, such as the temporal squama, frontal sinus region, mastoid cell region, or fracture sites. Note the types of procedures

https://doi.org/10.13004/kjnt.2023.19.e39

during which the hemorrhage occurred (**TABLE 1**). Most cases involve posterior fossa or cervical spine pathology, likely necessitating pin placement in the temporal region. Careful consideration should be given to avoid major vessels and nerve structures. Avoid inserting pins into the belly of the temporalis muscle, as it can result in extensive bleeding and reduced grasp rigidity. Additionally, antibacterial ointments should be used on of the pins to prevent infections of the pin site and air embolisms when removing the clamp.

- Ensure Correct Force Distribution: Pin placement should mirror the skull's greatest diameter between opposing pins to prevent "Soccer ball effect,"[23] which could increase the risk of slippage. The height of the pin position, that leads to the most stable and rigid grasp, according to Wang et al.[26], is the region of the superior temporal line and the diameter can be easily identified by placing a sweat band at this level (**FIGURE 4**). This position provides not only the best grasp but also the safest position with respect to significant anatomical structures. Initial placement of the two pins, on the lower side of the grasp, helps distribute gravity's force over a greater area.

- Adjust pressure properly: After the correct placement, an appropriate holding pressure must be applied. From our perspective, this is one of the most significant advantages of the Mayfield system. The pressure can be adjusted to the required level using a side screw. For adults, appropriate pressure range between 27–36 kg (60–80 pounds), which corresponds to numbers 3 and 4 on the scale. However, this situation is complex for children, as adult pins are not recommended for those under 5 years of age.[9] This emphasizes the need for alternative methods of fixation for very young individuals, such as the horseshoe headrests or combined systems (**FIGURE 5**). If an invasive HID is used, the pressure must be adjusted according to patient age.

- Safe removal: When removing the clamp, the patient's head should always be at the heart level to prevent negative pressure in the upper-body veins, reducing the risk of air embolism. First, we remove the single upper pin, followed by the double pins. If bleeding occurred, the defects were treated with stitches or prolonged pressure.

As shown in **TABLE 1**, outcomes vary on a case-by-case basis. Some patients experienced permanent neurological deficits post-event, and most required at least one surgical revision, with some even requiring multiple surgical revisions due to a complicated course. To prioritize prevention, it's crucial to meticulously follow the aforementioned instructions. It is also advisable to check CT scans' bone windows before applying the clamp (**FIGURE 3**), particularly

FIGURE 4. Skull clamp positioning.
The skull pins should be applied within the area covered by the sweatband.

https://doi.org/10.13004/kjnt.2023.19.e39

FIGURE 5. An example of non-invasive head fixation.

when significant hydrocephalus or chronically elevated ICP is present, or in pediatric cases. This practice may aid in identifying regions where pin placement should be avoided.

CONCLUSION

EDH is a rare but potentially serious complication associated with HID use. Our examination has underscored the significance of considering certain factors that elevate the risk of this complication. Specifically, we have identified chronic hydrocephalus, improper pin positioning, younger patient age, and specific clinical scenarios as contributors to this heightened risk. Therefore, neurosurgeons should be vigilant, keeping this knowledge at the forefront of their decision-making processes when confronted with unexpected clinical deterioration, whether during surgery or postoperatively.

REFERENCES

1. Baerts WD, de Lange JJ, Booij LH, Broere G. Complications of the Mayfield skull clamp. **Anesthesiology** 61:460-461, 1984
PUBMED | CROSSREF
2. Beuriat PA, Jacquesson T, Jouanneau E, Berhouma M. Headholders' - complications in neurosurgery: a review of the literature and recommendations for its use. **Neurochirurgie** 62:289-294, 2016
PUBMED | CROSSREF
3. Bindra A, Rath GP, Chowdhury T, Mishra P. Epidural hematoma at skull pin fixation sites may cause refractory intraoperative brain bulge. **J Clin Anesth** 24:509-510, 2012
PUBMED | CROSSREF
4. Erbayraktar S, Gökmen N, Acar U. Intracranial penetrating injury associated with an intraoperative epidural haematoma caused by a spring-laden pin of a multipoise headrest. **Br J Neurosurg** 15:425-428, 2001
PUBMED | CROSSREF
5. Fernández-Portales I, Cabezudo JM, Lorenzana L, Gómez L, Porras L, Rodríguez JA. Traumatic aneurysm of the superficial temporal artery as a complication of pin-type head-holder device. Case report. **Surg Neurol** 52:400-403, 1999
PUBMED | CROSSREF

https://doi.org/10.13004/kjnt.2023.19.e39

6. Furuya T, Yamazaki M, Nemoto T, Okawa A, Ohtori S. Skull fracture and epidural hematoma caused by use of a Mayfield skull clamp in an adult patient with chronic hemodialysis: a case report. **J Med Case Reports** 15:154, 2021
PUBMED | CROSSREF
7. Hiwatari T, Yamahata H, Yonenaga M, Fujio S, Higa N, Hanaya R, et al. The incidence of depressed skull fractures due to the use of pin-type head frame systems in the adult population: 10-year experience of a single neurosurgical center. **World Neurosurg** 155:e395-e401, 2021
PUBMED | CROSSREF
8. Inagawa T, Takeda T, Taguchi H, Kamiya K, Yamada T. Traumatic middle meningeal arteriovenous fistula caused by three-point skull fixation. Case report. **J Neurosurg** 60:853-855, 1984
PUBMED | CROSSREF
9. Integra LifeSciences Corporation. MAYFIELD Infinity XR2 Skull Clamp (A2114) Instruction Manual. Princeton, NJ: Integra LifeSciences Corporation, 2009 (https://www.cardion.cz/file/1238/mayfield-xr2-brochure.pdf) [Accessed September 6, 2023].
10. Jetté N, Lix LM, Metge CJ, Prior HJ, McChesney J, Leslie WD. Association of antiepileptic drugs with nontraumatic fractures: a population-based analysis. **Arch Neurol** 68:107-112, 2011
PUBMED | CROSSREF
11. Jha NK, Ebrahim S, Fallah A, Cenic A, De Villiers RA. Pin-site epidural hematoma in an adult case of chronic hydrocephalus with associated thinning of the cranium. **Br J Neurosurg** 23:211-212, 2009
PUBMED | CROSSREF
12. Khandelwal A, Gupta S, Prabhakar H, Burman S. Venous air embolism following application of Mayfield head clamp: a word of caution. **Indian J Anaesth** 62:1002-1003, 2018
PUBMED | CROSSREF
13. Krishnan P, Kumar SK, Kartikueyan R, Patel SM. Pin-site epidural hematoma: a catastrophic complication of cranial fixation in a child. **J Neurosci Rural Pract** 7:286-289, 2016
PUBMED | CROSSREF
14. Lee MJ, Lin EL. The use of the three-pronged Mayfield head clamp resulting in an intracranial epidural hematoma in an adult patient. **Eur Spine J** 19 Suppl 2:S187-S189, 2010
PUBMED | CROSSREF
15. Lundgren M, Elfallal W, Park D. Acute postoperative unilateral frontalis palsy with spontaneous resolution after placement of Mayfield skull clamp. **J Am Acad Orthop Surg Glob Res Rev** 4:00123-00125, 2020
PUBMED | CROSSREF
16. Matouk CC, Ellis MJ, Kalia SK, Ginsberg HJ. Skull fracture secondary to application of a Mayfield skull clamp in an adult patient: case report and review of the literature. **Clin Neurol Neurosurg** 114:776-778, 2012
PUBMED | CROSSREF
17. Naik V, Goyal N, Agrawal D. Pin site bilateral epidural hematoma - a rare complication of using Mayfield clamp in neurosurgery. **Neurol India** 59:649-651, 2011
PUBMED | CROSSREF
18. Parenrengi MA, Adhiatmadja F, Arifianto MR, Apriawan T, Fauzi AA, Servadei F. Bilateral skull fracture with massive epidural hematoma secondary to pin-type head fixation in a pediatric patient: case report and review of the literature. **Int J Surg Case Rep** 62:43-49, 2019
PUBMED | CROSSREF
19. Prabhakar H, Ali Z, Bhagat H. Venous air embolism arising after removal of Mayfield skull clamp. **J Neurosurg Anesthesiol** 20:158-159, 2008
PUBMED | CROSSREF
20. Sade B, Mohr G. Depressed skull fracture and epidural haematoma: an unusual post-operative complication of pin headrest in an adult. **Acta Neurochir (Wien)** 147:101-103, 2005
PUBMED | CROSSREF
21. Serramito-García R, Arcos-Algaba A, Santín-Amo JM, García-Allut A, Bandín-Diéguez FJ, Gelabert-González M. Epidural haematoma due to an headrest in an adult. **Neurocirugia (Astur)** 20:567-570, 2009
PUBMED
22. Taira T, Tanikawa T. Breakage of Mayfield head rest. **J Neurosurg** 77:160-161, 1992
PUBMED
23. Thijs D, Menovsky T. The Mayfield skull clamp: a literaturereview of its complications and technical nuances for application. **World Neurosurg** 151:102-109, 2021
PUBMED | CROSSREF
24. Tyagi G, Bhat DI, Devi BI, Shukla D. Multiple remote sequential supratentorial epidural hematomas-an unusual and rare complication after posterior fossa surgery. **World Neurosurg** 128:83-90, 2019
PUBMED | CROSSREF

25. Vitali AM, Steinbok P. Depressed skull fracture and epidural hematoma from head fixation with pins for craniotomy in children. **Childs Nerv Syst** 24:917-923, 2008
PUBMED | CROSSREF

26. Wang BY, Wu TK, Liu H, Hong Y, Meng Y. *In vitro* stability analysis of the three-pronged Mayfield head clamp using pins in four different positions on the skulls. **Int J Clin Exp Med** 11:5736-5742, 2018

27. Yan HJ. Epidural hematoma following use of a three-point skull clamp. **J Clin Neurosci** 14:691-693, 2007
PUBMED | CROSSREF

https://doi.org/10.13004/kjnt.2023.19.e39