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Case Report

Neuronavigation as a minimally invasive tool in the treatment of intracranial gunshot injuries

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Abstract: Gunshot injury is the most common cause of penetrating brain injury. The in-hospital mortality for civilians with penetrating craniocerebral injury is 52-95%. There are many surgical techniques suitable for the treatment of survivors. We report a surgical technique consisting of neuronavigation guidance for wound treatment with smaller incisions and craniotomies, followed by bullet removal if feasible. We report case of a 15 year old male patient who sustained an accidental firearm injury to the occipital region, submitted to surgical treatment that consisted in a minimally invasive approach guided by neuronavigation. Immediate neurological examination showed inferior homonymous quadrantanopsia alone as a clinical finding. Patient was discharged after one week, and no complications arised in follow-up. We conclude that using neuronavigation as a tool was effective in the reported case and that minimally invasive neurosurgical techniques may be a safe and efficient option for the treatment of traumatic brain injuries caused by firearm projectiles.

Keywords: Firearm injury, traumatic brain injury, neuronavigation, gunshot injury, penetrating brain injury

Introduction

Traumatic injuries are considered a major cause of death in individuals younger than 45 years [1, 16]. Gunshot injury is the most common cause of penetrating brain injury [2, 15]. The in-hospital mortality for civilians with penetrating craniocerebral injury is 52-95% depending on the proportion of suicide victims in the series [4] imaging findings in association with the neurological status are used to determine which patients are candidates to the surgical treatment [3]. Mortality at the scene of the accident is around 70%. Of the survivors, 50% die within 24 hours [11].

We report the case of a patient that sustained a gunshot injury to the right occipital region of the head and treated with only standard enter wound treatment plus novel neuronavigation-assisted projectile removal with posterior dural and skull reconstruction. Our objective is to demonstrate this approach and discuss its effectiveness as a treatment and in terms of patient safety.

Case report

A 15 years old male patient, with no prior comorbities, sustaining a firearm injury to the right occipital region. The projectile penetrated the occipital bone and was lodged at an approximate depth of 3 cm, at the subcortical region of the occipital lobe and at approximately 2 cm to the right of the midline. He was drowsy on admission, with a 14 points at Glasgow Coma Scale score and 110×70 mmHg arterial blood pressure. Pupils were isochoric and reactive and the patient presented no neurological focal deficits. A Head CT scan was obtained to determine brain tissue injury extent and the projectile's lodging location (**Figure 1**).

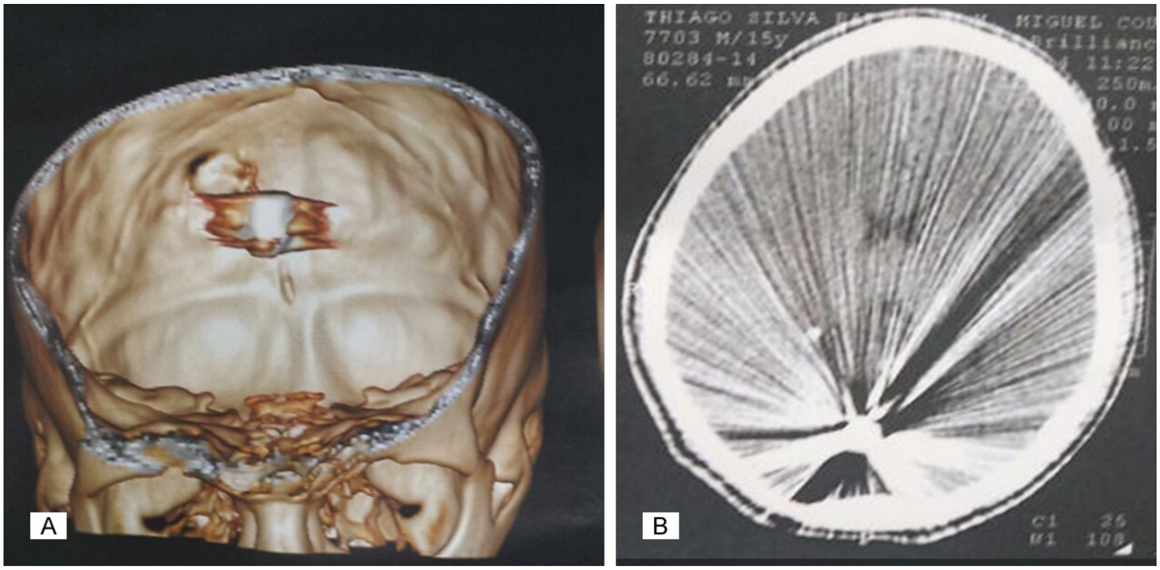

Figure 1. Preoperative images, showing artifact generated by the projectile. A: 3D Volume reconstruction of head CT-Scan. B: CT-scan section in the axial plane.

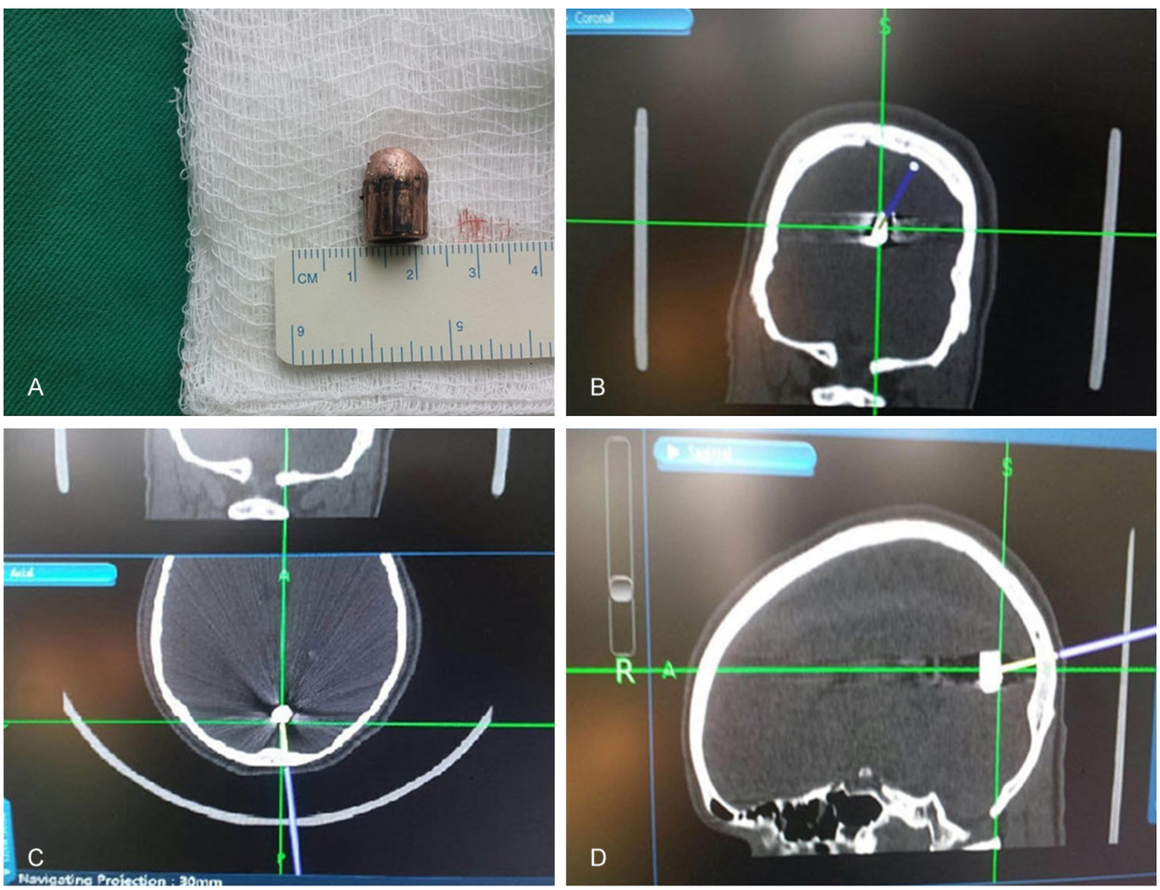

Figure 2. A: Projectile, after removal. B-D: CT-Scan and neuronavigation system determining the precise location of the projectile, thus allowing for a minimally invasive surgery.

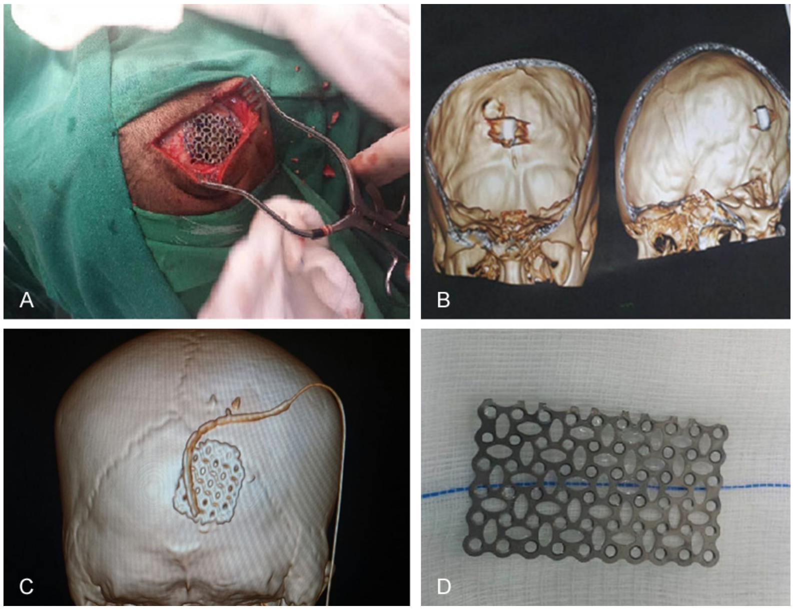

Figure 3. A: Titanium plate being placed for bone repair. B: Post-operative CT-scan, showing removal of projectile. C: 3D volume reconstruction of a CT-Scan, showing titanium plate in place. D: Titanium plate before placement.

Neurosurgical treatment and post-operative care

The surgical approach was guided by a neuronavigation device (Medtronic StealthStation S7 Surgical Navigation System) using the patient's head CT scan (Phillips™ brilliance multislice 16 channels, 140 kV) for the neuronavigation protocol (**Figure 2**). Hence, a small craniotomy was made possible, allowing the projectile (**Figure 2**) to be removed, dura-mater repaired, and the bone flap was replaced with a customized titanium plate (**Figure 3**).

The patient remained stable throughout the whole procedure, with minimal blood loss and there were no complications during surgery.

Patient stability in post-operative scenario allowed dismissing of intensive unit care after 1 day. Immediate neurological examination showed inferior homonymous quadrantanopsia alone as a clinical finding. Patient was discharged after one week, and no complications arised in follow-up.

Discussion

Treatment of gunshot wounds with early decompressive craniectomies and aggressive critical care management has been considered the most suitable approach for wartime injuries according to studies using military populations, but these differ greatly from civilian gunshot wound injuries, which may be less severe due to lower-velocity projectiles [6], allowing for a less invasive therapy.

The use of neuronavigation is most commonly implied in the removal of complex intracranial tumors due to the possibility of further analysis of the anatomical correlations of these lesions with nearby vital structures such as nerves and vessels during surgery [8]. It has also used in complex approaches to the skull base [17], blunt trauma to the orbita [4], endoscopic approaches 9 and refractory epilepsy surgery [13]. While this may be a valid strategy, caution is advised since the anatomical disortions that may occur during surgery remain a common pitfall associated to the technique [7]. Other authors have reported successful experiences when applying neuronavigation to gunshot PBI [2], although not always removing the projectile in a primary approach or at all [12] since the position of metallic fragments may or may not be suitable for removal.

By using neuronavigation technology in a less invasive approach, not yet widely used according to current literature, bone fragment removal and gunshot injury management is achieved with smaller craniotomies and skin incisions. Therefore, by reducing surgical exposure, these procedures carry a reduced risk of infection, minimal tissue stress and fewer complications in general as opposed to the use of other methods, such as larger and wider standard craniotomies. Minimally invasive surgeries also require less time, since less surgical hemostasis is demanded, as well as lower doses of sedatives and other intraoperative drugs, resulting in a better overall post-operative clinical scenario, which contributes to better patient prognosis and safety [10].

Aside from neuronavigation, that may be unavailable, we believe other minimally invasive techniques may be useful, such as intraoperative ultrasound, that is already being used as an supportive method for removing brain tumors, for drainage of brain abscesses and in a series other applications [14]. With ultrasound, it is possible to distinguish different tissues and materials such as bony or metal fragments, visualize hematomas or liquid collections, as well as vessels when using the Doppler function [14] with a relatively low cost, minimal preparation time and simplified usage [5].

Conclusions

Neuronavigation was effective in the reported case and minimally invasive neurosurgical techniques may be a safe option for the treatment of traumatic brain injuries caused by firearms, when fragment removal is feasible and when there is no indication of other common, and more invasive, strategies.

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Disclosure of conflict of interest

None.

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