



Minimally Invasive Microsurgery for Cerebral Contusions

Microcirurgia minimamente invasiva para tratamento de contusões cerebrais

Rodrigo Moreira Faleiro¹ Vítor Vieira de Souza Moraes¹ João Tiago Alves Belo¹
Thales Francisco Ribeiro¹ Chiara Menezes Greco² Vitor Bernardes Rossi²

¹ Neurosurgery Department, Hospital Felício Rocho, Belo Horizonte, MG, Brazil

² Faculdade de Ciências Médicas de Minas Gerais, Belo Horizonte, MG, Brazil

Address for correspondence Vítor Vieira de Souza Moraes, MD, Faculdade de Ciências Médicas de Minas Gerais, Belo Horizonte, Minas Gerais, Brazil (e-mail: vieirafcmmg@gmail.com).

Arq Bras Neurocir

Abstract

Keywords

- brain contusion
- minimally invasive surgery
- brain trauma
- traumatic brain injuries
- microsurgery
- trauma surgery

Introduction Traumatic brain injury (TBI) is among the main causes of death and neurological sequelae worldwide. Injuries are classified as diffuse (diffuse axonal injury and brain swelling) or focal (cerebral contusion [CCo], epidural hematoma, and acute subdural hematoma). Among all TBIs, CCos are the most frequent focal lesion, and treatment modalities are many. Hematoma evacuation using large craniotomies has been well described in the literature. The main goal of the present study is to discuss the advantages of minimally invasive approaches for the treatment of CCos, regarding operative time, blood loss, and postoperative tomographic results.

Methods An integrative literature review was conducted on the SciELO, LILACS, and PubMed databases. Seven case reports were included in the present study. Retrospective data collection was performed, analyzing gender, age, Glasgow coma scale score on hospital admission, surgical approach, and postoperative (tomographic) results.

Results The minimally invasive keyhole approach was used in seven patients with CCos. The supraorbital approach ($n = 5$) was performed for frontal lobe contusions, and the minipterional approach ($n = 2$) was performed for temporal lobe contusions. All cases had adequate hematoma evacuation, confirmed by postoperative computed tomography scans.

Conclusion The minimally invasive approaches were effective for hematoma evacuation, with adequate clinical and radiological postoperative results.

received
June 10, 2021
accepted
January 18, 2022

DOI <https://doi.org/10.1055/s-0042-1744115>.
ISSN 0103-5355.

© 2023. Sociedade Brasileira de Neurocirurgia. All rights reserved.
This is an open access article published by Thieme under the terms of the Creative Commons Attribution-NonDerivative-NonCommercial-License, permitting copying and reproduction so long as the original work is given appropriate credit. Contents may not be used for commercial purposes, or adapted, remixed, transformed or built upon. (<https://creativecommons.org/licenses/by-nc-nd/4.0/>)
Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Introdução O traumatismo cranioencefálico se encontra entre as principais causas de óbito e sequelas neurológicas na estatística mundial. As lesões são classificadas como difusas (lesão axonal difusa e edema cerebral traumático) ou focais (contusões cerebrais [CoC], hematoma epidural, e hematoma subdural agudo). Dentre todos os tipos de lesões cerebrais traumáticas, as contusões são a lesão focal mais comum, e são reservadas a elas múltiplas modalidades de tratamento. O principal objetivo desse estudo é discutir as vantagens dos acessos minimamente invasivos no tratamento de contusões cerebrais, especialmente no que concerne à duração do procedimento, perda sanguínea e resultados tomográficos pós-operatórios.

Métodos Uma revisão integrativa de literatura foi conduzida nas plataformas Scientific Electronic Library Online (SciELO), Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS) e PubMed. Sete relatos de caso foram incluídos neste estudo. A coleta retrospectiva de dados foi realizada com a análise das seguintes variáveis: gênero, idade, escala de coma de Glasgow à admissão, acesso cirúrgico utilizado e resultados tomográficos pós-operatórios.

Resultados O acesso cirúrgico minimamente invasivo foi utilizado em sete pacientes com CoC. O acesso supraorbital ($n = 5$) foi usado para tratar contusões frontais, enquanto o acesso minipterional ($n = 2$) foi usado para o tratamento de contusões temporais. Em todos os casos, foi obtida drenagem satisfatória do hematoma, confirmada por meio de tomografias pós-operatórias.

Conclusão Os acessos minimamente invasivos foram efetivos para evacuação dos hematomas intraparenquimatosos, com resultados clínicos e tomográficos favoráveis.

Palavras-chave

- contusão cerebral
- cirurgia minimamente invasiva
- trauma cerebral
- lesões cerebrais traumáticas
- microcirurgia
- cirurgia de trauma

Introduction

Traumatic brain injury (TBI) is among the three main causes of death in several developed and developing countries. Worldwide, ~ 5.4 million people die from TBI every year, with 90% of deaths occurring in underdeveloped or developing countries.¹ Neurological sequelae are frequent. In Brazil, it is estimated that > 1 million people live with neurological sequelae resulting from TBI.

There are many intracranial injuries caused by TBI. They may be classified as diffuse (diffuse axonal injury and brain swelling) and focal injuries (cerebral contusion [CCo], epidural hematoma, and acute subdural hematoma).^{2,3} Cerebral contusion is the most frequent focal lesion in blunt head trauma (~ 35%), although < 20% of these are treated with surgery. Due to the great epidemiological relevance of CCo, it is crucial to understand its physiopathology and the most adequate treatment for the special cases that deserve a surgical approach, regarding efficiency of the procedure and good outcomes.

Case Series – Data Collection

The authors present in the present case series results of the surgical treatment of brain contusions, performed through keyhole approaches, in our institution (Hospital Pronto Socorro João XXIII, Belo Horizonte, MG, Brazil), a level I trauma center.

Data was collected regarding gender and age of the patients, as well as Glasgow Outcome Scale during hospital

admission, surgical approach, and effectiveness of the procedure. Nine cases of patients with unilateral or bilateral frontal or temporal contusions who underwent evacuation through the supraorbital or minipterional keyhole approach, respectively, were analyzed. All patients were male, with an average age of 49.2 ± 21.85 years old (range: 7–69 years old). Family members provided informed consent for the present study.

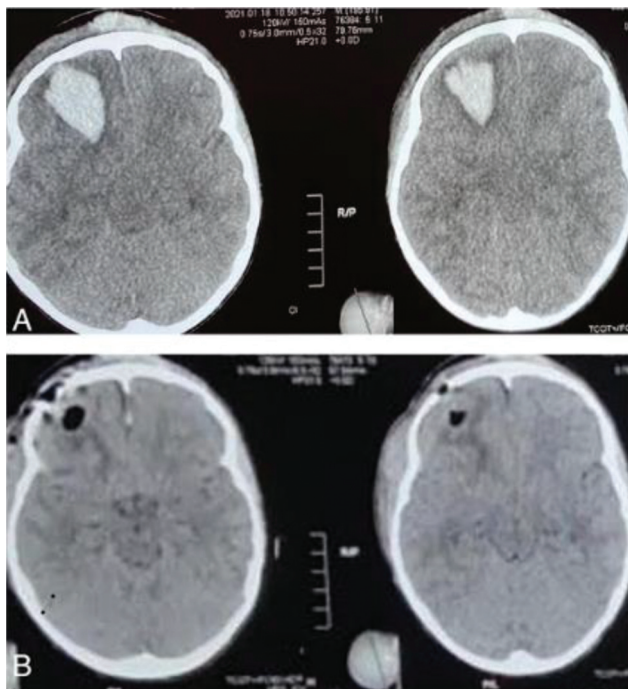
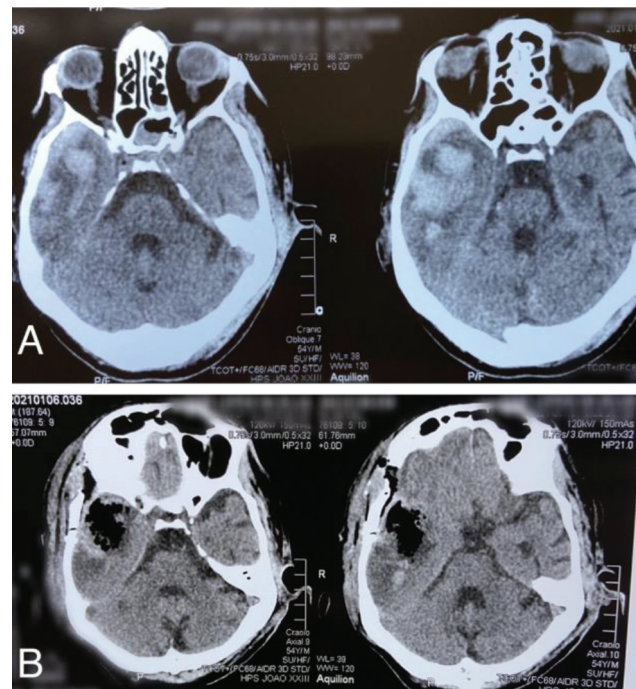
Case Series – Results

As many patients who present with CCo after TBI have concomitant intracranial injuries, which may be other focal injuries (epidural and subdural hematomas) and/or diffuse axonal injury (DAI), neurological outcomes may be heterogeneous for these groups. For this reason, the authors used in this study, as a result of effectiveness of the procedure, adequate evacuation of the intraparenchymal hematoma, confirmed by a postoperative computed tomography (CT) head scan, and the absence of need of a new surgery to treat the CCo (new hematoma evacuation surgery; decompressive craniectomy).

All nine cases submitted to minimally invasive surgical approaches (supraorbital keyhole or minipterional craniotomy) presented with satisfactory tomographic postoperative results, as shown in ►Table 1. ►Figures 1 and 2 are used as examples of adequate postoperative tomographic results, from two patients included in the present study who were submitted to a minimally invasive approach for the treatment of CCo.

Table 1 Effectiveness of surgical drainage of brain contusions

Gender	Age (years old)	Glasgow Coma Scale	Chosen approach	Result
Male	43	10	Supraorbital	Effective
Male	69	8	Supraorbital	Effective
Male	69	10	Supraorbital	Effective
Male	60	9	Supraorbital	Effective
Male	57	13	Minipterional	Effective
Male	40	8	Minipterional	Effective
Male	7	13	Supraorbital	Effective
Male	61	11	Supraorbital	Effective
Male	21	13	Minipterional	Effective

**Fig. 1** Pre- (A) and postoperative (B) head computed tomographies of an effective supraorbital approach.**Fig. 2** Pre- (A) and postoperative (B) head computed tomographies of an effective minipterional approach.

Discussion

Cerebral contusions may arise at the direct impact site (coup injury) or at the diametrically opposite location of the impact (contrecoup injury), and they are more common at the temporal and frontal poles. Several studies have demonstrated that the CCo is formed by a “central necrotic core” and by the pericontusional penumbra, which has a lower-than-ischemic-threshold regional cerebral blood flow, and where viable nervous tissue may be saved when the intraparenchymal hematoma is treated properly.⁴

At the center of the injury (central core), organelle destruction occurs, creating a highly osmolar region. This hyperosmolar core promotes water accumulation into the injury, which leads to contusion growth, associated with hemorrhagic progression at the pericontusional penumbra.⁴

Based on the aforementioned concepts, hematoma evacuation surgery is proposed by the authors, not only to decrease local mass effect caused by the lesion, but also in order to avoid hemorrhage progression and increases on hematoma volume.

The main goal of the present study is to propose a new standard method of treating CCo, specifically the ones that require surgical treatment and may be approached using keyhole craniotomies. The authors propose that using smaller craniotomies and less invasive approaches, neurosurgeons will be able to treat properly intraparenchymal hematomas, with satisfactory clinical and radiological outcomes.

The supraorbital and minipterional keyhole approaches, performed using a minimally invasive craniotomy (as shown in **Figure 3**, through the schematic drawing, done by one of the authors), were first proposed in trauma surgery by Zhang



Fig. 3 Schematic drawing illustrating the keyhole approaches – incisions and craniotomies.

et al.,⁵ seeking smaller approaches for the treatment of focal brain injuries. The goals of the technique are: avoidance of hemorrhagic progression of CCos, reduction of perilesional edema associated with the process of blood resorption,⁶ and the immediate resolution of mass effect on the cerebral parenchyma, along with the advantages of a shorter operating time, reduction of intraoperative blood loss and, consequently, a lesser metabolic response to trauma, as proposed by Figueiredo et al.⁷

Trauma surgery is historically known for large craniotomies for the treatment of intracranial hematomas, not only for epidural and subdural hematomas, but also for CCos. Nonetheless, small areas of corticectomy are needed to approach the central core of intraparenchymal hematomas and to provide adequate hematoma evacuation and hemo-

stasis. Therefore, why not apply the concept of the keyhole approach to directly access the desired location of the corticectomy?

Technical Note

Supraorbital Keyhole Approach

Skin Incision and Soft Tissue Dissection

The skin incision consists of a slightly curvilinear incision, along the superciliary arch, following the outline of the orbital rim, of ~ 3 to 4 cm in length. Care must be taken to avoid injury to the medial superficial neurovascular structures (supraorbital nerves and artery) near the supraorbital foramen. Some authors recommend performing the incision exactly in the haired area, in order to cover the scar and achieve a pleasing cosmetic outcome; however, others associate this technique with a risk of alopecia and worse cosmetic results, which may be avoided with an incision just above the eyebrow.

The subcutaneous tissue is dissected upwards, in a cranial direction, while the skin flap is gently mobilized downwards and retracted with stitches to expose the frontal belly of the occipitofrontal, the orbicular, and the temporal muscles.

The frontal muscles are cut with a scalpel or monopolar cautery, through a linear cut, parallel to the glabella. The temporal muscle is stripped from its bony insertion and mobilized laterally, using blunt dissection just enough to expose the pterion. The two separate frontal muscle bellies are retracted upwards and downwards (along with the orbicular muscle). The temporal muscle is retracted laterally with wound hooks in order to expose the fronto-orbital keyhole. The pericranium is dissected away from the center of the surgical field before proceeding with the craniotomy.

Craniotomy and Dural Opening

A single frontobasal burr hole is made, posterior to the temporal line, using a high-speed drill, at the level of the frontal skull base. Then, a “C” shaped craniotomy is performed with a high-speed drill, with its base parallel to the glabella, creating a bone flap with 2 to 3 cm in its largest diameters. Drilling of the inner table of the bone above the orbital rim may be performed in order to achieve better exposure of the basal surface of the skull and less brain retraction.

Durotomy can be performed through a linear or curvilinear incision, with its base toward the skull base, exposing the underlying brain parenchyma, using dural tenting sutures. ►**Figure 4** illustrates the supraorbital approach regarding the skin incision, the craniotomy, and the dural opening.

Hematoma Evacuation and Surgical Hemostasis

Through a small corticectomy (~ 1 to 2 cm), the core of the CCo is properly assessed, especially when using magnifying tools (surgical microscope). Then, the hematoma is carefully evacuated, using suction and wound irrigation. Hemostasis is performed under magnification, with gentle coagulation of

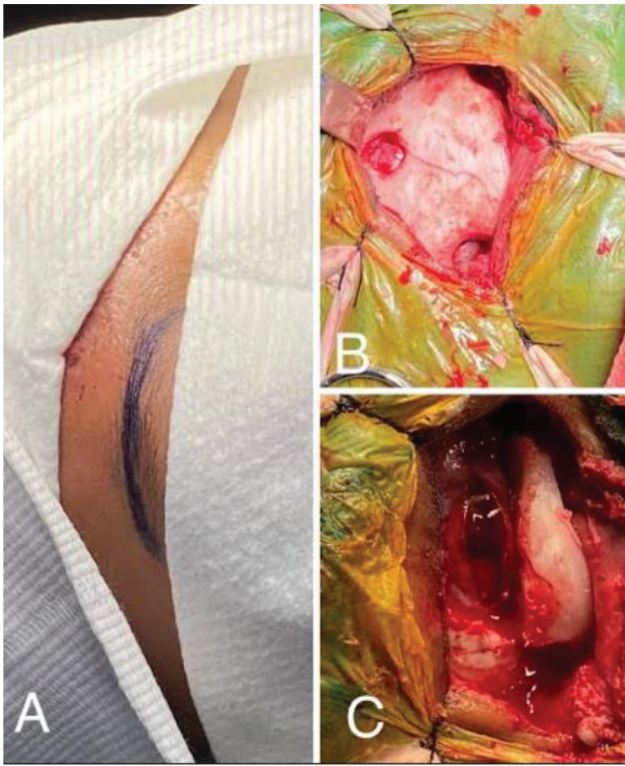


Fig. 4 Skin incision (A); craniotomy (B) and dural opening (C) are illustrated.

the friable brain parenchyma, irrigation, and use of hemostatic agents (when necessary).

Wound Closure

Watertight dural closure is carried after assurance of adequate hemostasis. The bone defect may be covered using the bone flap and titanium plates, or only a titanium mesh.

The muscle and subcutaneous tissue are closed with interrupted sutures, and the skin may be closed with intradermal, running, or interrupted sutures. As there is limited tissue trauma and bleeding using this technique, a surgical drain is not required.⁸

Minipterional Craniotomy

Surgical Incision and Tissue Dissection

This technique consists of performing a curvilinear scalp incision, ~ 1 cm anterior to the auricular tragus, which corresponds to the anterior root of the zygomatic arch, at the anterior edge of the hairline, extending rostrally towards the ipsilateral hemipupillary line, with an extension of ~ 5 cm. After dissection and exposure of the temporal muscle fascia, with preservation of the superficial temporal artery, an arcuate incision of the temporal fascia, in its most posterior extension, is performed, followed by subfascial dissection (as proposed by Spetzler et al.,⁹ unlike the original interfascial technique, described by Yasargil¹⁰), with careful retraction of the skin flap, in order to avoid injuries to the frontal branch of the facial nerve. After subfascial dissection and protection of the deep layer of the temporal muscle fascia, along with the fat

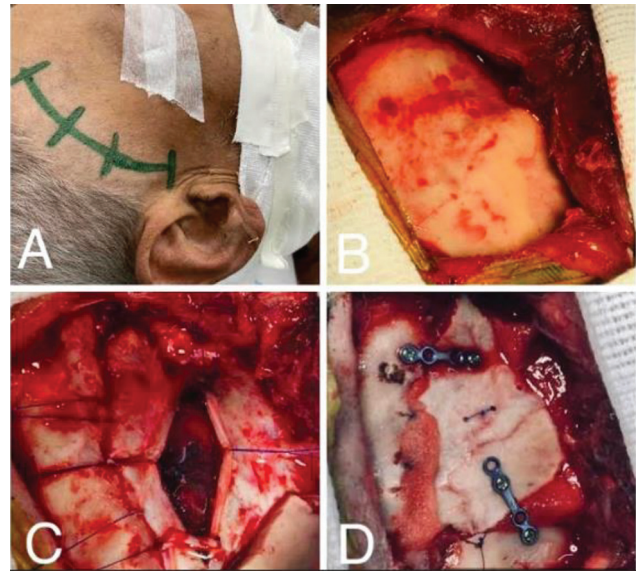


Fig. 5 Skin incision (A); craniotomy (B), dural opening (C), and wound closure (D) are illustrated, from the minipterional approach.

pad, a myofascial flap is then retracted with wound hooks, and subperiosteal dissection of the frontotemporal region is performed in order to expose the pterion.

Craniotomy and Dural Opening

A burr-hole is placed at the upper limit of the frontozygomatic suture, below the temporal line; another burr-hole is placed at the pterion, and a third burr-hole is made at the basal region of the temporal bone. The craniotomy is completed after connecting the three burr-holes with a high-speed drill. The bone flap consists of the lateral part of the sphenoid bone, of the lower part of the frontal bone, and of a small part of the temporal bone (squamous part).

Durotomy may be performed using a curvilinear or a linear incision in order to expose the cerebral cortex and the underlying contusion. Dural tack-up sutures may be of help in order to expose the brain parenchyma. ►**Figure 5** illustrates the minipterional approach, regarding the skin incision, the planning of the craniotomy, the dural opening, and the cranioplasty.

Hematoma Evacuation and Surgical Hemostasis

After adequate exposure of the brain parenchyma, corticectomy is performed at the contusional area, with delicate dissection, in order to gain access to the core of the contusion. After evacuation of the hematoma, hemostasis is performed with bipolar cautery, irrigation, and use of hemostatic substances (if necessary).

Wound Closure

Dura mater closure is performed in a watertight fashion. Pericranial grafts may be used if duraplasty is necessary. The bone flap may be reimplanted with titanium implants or with suture threads. The temporal muscle and fascia are attached together, with interrupted sutures, just like the subcutaneous tissue. Skin closure may be performed with interrupted or running sutures.^{7,11}

Conclusion

As analyzed by the effectiveness of minimally invasive approaches for the treatment of CCo, using microscopic magnification, the authors offer, through the present study, a promising guideline for the surgical treatment of traumatic intraparenchymal hematomas. With impelling results on the efficacy of hematoma evacuation, shorter operating times, and minor intraoperative blood losses, this new approach may be used as a standard protocol in the future of trauma surgery.

Conflict of Interests

The authors have no conflict of interests to declare.

References

- 1 Iaccarino C, Carretta A, Nicolosi F, Morselli C. Epidemiology of severe traumatic brain injury. *J Neurosurg Sci* 2018;62(05): 535–541. Doi: 10.23736/S0390-5616.18.04532-0
- 2 Miller JD, Butterworth JF, Gudeman SK, et al. Further experience in the management of severe head injury. *J Neurosurg* 1981;54 (03):289–299. Doi: 10.3171/jns.1981.54.3.0289
- 3 Bullock M.R., et al. Surgical management of traumatic parenchymal lesions. *Neurosurgery*. 2006;58:S25–S46. Doi: 10.1227/01.NEU.0000210365.36914.E3
- 4 Kurland D, Hong C, Aarabi B, Gerzanich V, Simard JM. Hemorrhagic progression of a contusion after traumatic brain injury: a review. *J Neurotrauma* 2012;29(01):19–31. Doi: 10.1089/neu.2011.2122
- 5 Zhang S, Qian C, Sun G, Li X. Clinical application of the supraorbital key-hole approach to the treatment of unilateral-dominant bilateral frontal contusions. *Oncotarget* 2017;8(29):48343–48349. Doi: 10.18632/oncotarget.15983
- 6 McBride W, Brock DG. Intracranial epidural hematoma in adults. UptoDate [Internet]. 2020 May 27 [cited 2021 Feb 1]:-. Available from: https://www.uptodate.com/contents/intracranial-epidural-hematoma-in-adults?sectionName=MANAGEMENT&topicRef=4826&anchor=H12&source=see_link#H12
- 7 Figueiredo EG, Deshmukh P, Nakaji P, et al. The minipterional craniotomy: technical description and anatomic assessment. *Neurosurgery* 2007;61(5, Suppl 2): ONS256–ONS264
- 8 Venkatakrishna R. Management of acute moderate and severe traumatic brain injury. Up to Date 2016.
- 9 Spetzler RF, Lee KS. Reconstruction of the temporalis muscle for the pterional craniotomy. Technical note. *J Neurosurg* 1990;73 (04):636–637. Doi: 10.3171/jns.1990.73.4.0636
- 10 Yasargi MG *Microneurosurgery: microsurgical anatomy of the basal cisterns and vessels of the brain, diagnostic studies, general operative techniques and pathological considerations of the intracranial aneurysms*. 1st ed [New York];1984
- 11 Figueiredo EG. Descrição técnica e avaliação anatômica da craniotomia minipterional [thesis]. São Paulo: Faculdade de Medicina, Universidade de São Paulo; 2008;53;