Skull Base Dural Reflection Models: Tool for Training at Resource Scarce Centres

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Method Article

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Abstract

Background

Skull base dural reflections are complex, and along with various ligaments joining sutures of skull base, are related to most important vessels like internal carotid arteries (ICA), vertebral arteries, jugular veins, cavernous sinus and cranial nerves make surgical approaches difficult and needs thorough knowledge and anatomy for safe dissection and satisfactory patient outcomes. Cadaver dissection is much more important for training of skull base anatomy in comparison to any other subspecialty of neurosurgery, however, such facilities are not available at most of the training institutes more so in low and middle income countries (LMICs).

Methods

A glue gun (100-watt glue gun, Aptech deals, Delhi, India) was used to spread glue over the superior surface of bone of skull base over desired area (anterior, middle or lateral skull base). Once glue was spread over the desired surface uniformly, it was cooled under running tap water and the glue layer was separated from the skull base. Various neurovascular impressions were colored for ease of depiction and teaching.

Result

Inferior surface of dural reflections of the skull base is important for understanding neurovascular orientations of various structures entering or exiting the skull base. It was readily available, reproducible and simple for teaching neuroanatomy to the trainees of neurosurgery.

Conclusion

Skull base dural reflections made up of glue is an inexpensive, reproducible item which may be used for teaching neuroanatomy. It may be useful for trainees and young neurosurgeons especially at resource scarce health-care facilities.

Introduction

Skull base surgery has advanced tremendously in last couple of decades after emergence of advancements in techniques and technologies of endoscope optics, illumination in addition to increasing use of Neuronavigation, neurophysiological monitoring, specially designed instruments and drills. [4, 6, 8] However, training of skull base surgery is demanding as it needs strong concepts of neuroanatomy pertaining to neurovascular structures and their relationships to dural reflections of the skull base. Cadaver dissection is much more important for skull base surgery training than any other subspecialty of
neurosurgery. [3, 10] However, access to cadaver laboratories is a limiting factor in most of the developing countries including India. Recent data suggests approximately 112 public sector healthcare institutions are having training courses in neurosurgery and barring 7–8, none has facility of cadaver dissection even for basic neurosurgical training. [2]

Authors use artificial models of skull base dural reflections for training of trainees and young neurosurgeons and describe the technique of the same. It may be useful for skull base surgery training at resource scarce centres, especially those without cadaver dissection facilities, around the world.

**Technical Details**

Skull base bone was taken (Fig. 1) to make negative mould of upper surface, which represents skull base dura. Four regions of skull base dura were selected which are important from neuroanatomical perspectives for skull base surgery training.

1. Anterior cranial fossa (ACF) starting from crista galli/cribriform plates, plenum sphenoidale, tuberculum sella, anterior and posterior clinoids, sella and upper part of clivus and paramedian parts of middle cranial fossa beyond foramen ovale and foramen spinosum. (Figs. 2a and 3a)
2. One half of anterior, middle and posterior cranial fossae on right side. (Fig. 2b and 3b)
3. Planum sphenoidale, tuberculum sella, sella, anterior and posterior clinoids, middle cranial fossa till its lateral extent and upper parts of clivus, bilateral petroclival regions along with posterior surfaces of petrous bones. (Fig. 3c)
4. Tuberculum sella, sella, anterior and posterior clinoids, paramedian middle cranial fossae and anterior half of posterior fossa extending laterally up to just posterior to sigmoid sinuses and upto anterior margin of foramen magnum including occipital condyles, jugular foramen, hypoglossal foramen and internal auditory meatus. (Fig. 3d)

Glue gun (100-watt glue gun, Aptech deals, Delhi, India) was used with transparent glue (11 mm diameter) sticks to uniformly spread molten glue over selected regions, one region at a time. Special care was taken to avoid air pockets under the layer of the glue and put some glue into the skull base foramen which are important from anatomical point of view like optic foramen, foramen ovale, rotundum, spinosum, lacerum and superior orbital fissure, which allow important neurovascular structure to pass through or enter into the cranial cavity. Once glue was spread over the desired area, it was cooled under running water for 2–3 minutes. Once cooled, gradual separation of the glue layer was done without breaking the layer which usually becomes quite strong and separates easily. Glue layer separated represents dural reflections along with all the impressions of skull base surface including foramina. It was easy to use colored electrical wires to place in the foramen before application of molten glue to depict neurovascular structures like optic never by yellow electrical wires, internal carotid arteries (ICA) by red electrical wires, V1, V2, V3 branches of trigeminal nerves by yellow wires. Once settled after cooling, these colored wires were indicative of cranial nerves and arteries. (Figs. 2, 3 and 4) One can use it with (Fig. 5a) or without (Fig. 5b) marking relevant neurovascular structures by various acrylic colours like red,
blue and yellow for depicting arteries, veins/venous sinuses or nerves respectively. Marking of the neurovascular structures was done by senior faculty member to make it representative to the anatomical structures marked.

These can be made for different areas as per requirements for training of neurosurgery trainees. Approximate cost of the glue gun is 4-4.5 USD and glue sticks used for 3 or 4 areas cost less than 25 cents (1/4 USD).

Technique of making dural reflection model of central skull base is shown in the video (video 1).

Discussion

Skull base anatomy is considered one of the most difficult to understand in neurosurgical training, especially due to complex relationships of dural folds, skull base bone sutures, various ligaments and their complex relationships with neurovascular structures. [4, 6, 8] Inability to see its inferior aspect due to nasal sinuses, pterygoid plates with its muscles, mandibles, craniovertebral junction with its muscular attachments with the skull base makes it much more difficult to understand especially in the early part of neurosurgical career. Convexity dura and superior views of skull base dura in easily seen in cadaver specimens. Most of the transnasal cadaver dissection photos are available which only show sellar and some part of paramedian dura in extended endoscopic skull base approach articles (hard copy or digital). [3, 10] Even when they are available, it shows anatomical structures deep to the dura and appearance of basal dura from inferior aspect just after removal of bone of skull base is not available.

Authors feel that understanding orientations of neurovascular structures in the skull base region is the basic of training and glue models of skull base dura visible from the inferior aspect will be immensely helpful in training. It may be useful even for those who have access to cadaver dissection mainly because even cadaver dissection will not be able to show inferior aspect views of skull base dura except sellar and to some extent of parasellar area. [3]

The models made by the technique mentioned, represent real superior surface of the skull base provide a raw model representing inferior view of the skull base dura. One may mark various neurovascular structures over it on the inferior and superior surfaces for easy understanding for trainees. One can pass colored electrical wires to depict arteries, veins/venous sinuses and cranial nerves before spreading molten glue in which case marking will not be required.

Neuroanatomical models of various structures have immense scope in neurosurgical training which is not utilised even to its minimum. Physical models of skull base for preoperative planning are being made using 3-dimensional (3-D) printer which are technically challenging, resource driven and takes 6–24 hours to make one model based on type of 3-D printers. [1, 5, 9] Virtual models are being made available of some aspects in neurosurgery but physical models will be much more helpful in early part of the neurosurgical career. Virtual models are currently not accessible to all and are very costly. [7] Physical
models, except saw bone models of bones, available in other disciplines are of poor quality and can't be used currently for teaching and training purposes.

Authors feel that despite availability of cadaver dissection facilities for undergraduate students at most of the medical colleges and institutions, they are rarely being used for super-specialty training and teaching. Neuroanatomy teaching in undergraduate too is too basic and most of the specimens of brain and skull base are left unused despite it immense utility for neurosurgical training. Among various reasons, poor coordination between departments of anatomy and neurosurgery seems the most obvious. Integration of anatomy departments in various aspects of teaching and research activities of neurosurgery may be a positive step, which will greatly enhance quality of neurosurgery and skull base surgery teaching and training.

We conclude that glue models are inexpensive, reproducible, simple to make and can be widely used for teaching and training in skull base surgery.

**Declarations**

**Ethical Approval:** This study does not involve human or animal subjects therefore ethical approval was not required.

**Competing interests:** Each author/contributor has no any financial or other relationships that might lead to a conflict of interest.

**Authors' contributions:**

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**Funding:** Nil

**Availability of data and materials:** There is no dataset for this study. A short video of the procedure is being uploaded with the manuscript as ‘Related file’.
References


Video 1

Video 1 is not available with this version.

Figures
Figure 1

Shows superior surface of skull base with vault removed.
Figure 2

Shows molten glue applied over ACF (a) and right half of skull base (b) with red, white and blue electrical wires to depict ICA, cranial nerves (optic nerve, V1, V2 and V3 divisions of trigeminal nerve) and venous sinuses (sigmoid, superior and inferior petrosal) respectively.
Figure 3

Shows skull base dural fold models of ACF (a), right half of skull base (b), sellar region (c) and sellar and anterior half of posterior cranial fossa (d). Neuromuscular structures have been shown using electrical colored wires (for ACF and right half of skull base) or red (ICA), white (optic and V1, V2 and V3 divisions of trigeminal nerve) and blue (sigmoid, superior and inferior petrosal sinuses) acrylic colors (for sellar and posterior fossa dural reflection models).
Figure 4

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Figure 5

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