Research Article

Fiber Dissection Training Model for Neurosurgical Practice: White Matter Fiber Dissection with Klingler's technique in Bovine Brain

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Summary

Background: Our aim was to assess an alternative to human brain microsurgical white matter fiber dissection using bovine brain and Klingler's technique.

Methods: Eight previously frozen, formalin-fixed bovine brains were dissected from the lateral surface to the medial using the microscope.

Results: We started to dissect the lateral surface of the brain and exposed the main fiber bundles. Arcuate fibers are visible after peeling the frontal and parietal lobes and thereafter the temporal lobe. Beneath the arcuate fibers, superior longitudinal fasciculus – the connection between the frontal, parietal, temporal and occipital lobes are detected. Deepen the dissection in the central core of the brain makes the extreme capsule, external capsule, putamen, globus pallidus, internal capsule and anterior commissure visible.

Conclusions: Bovine brain is a reasonable alternative to human brain for white matter fiber dissection, especially for those starting to develop this skill. This method enhances the basic knowledge and the level of patience that is required for a successful outcome.

Key words: Bovine brain, fiber dissection, anatomy, neurosurgical practice, training model

INTRODUCTION

Nearly 80 years ago, Joseph Klingler introduced a new method of brain dissection that employed a freezing technique and eloquently revealed the white matter tracts(4). This method was a milestone, that inspired neuroscientists, anatomists, neurosurgeons, and brain imagers for more than three quarters of a century. White matter fiber dissection studies give neurosurgeons the added skill...
of developing safe surgical techniques when approaching brain lesions. There are of course white matter fiber dissection courses available to neurosurgeons to improve their surgical technique. However, not all trained neurosurgeons or those in training get a chance to attend such courses or have access to cadaveric brain at their institution. For this reason our aim was to find an alternative to practice microsurgical white matter fiber dissection in human and use the bovine brain while employing Klingler's technique.

MATERIAL AND METHODS
Eight bovine cerebral hemispheres (4 right and 4 left sides) were obtained from a butcher. The fresh brains were fixed in 10% formaldehyde for at least 40 days (Figure 1a). The arachnoid membrane and cerebral vessels were carefully removed (Figure 1b), and the hemispheres were frozen at -15°C for 15 days. Subsequently these were removed from the freezer and allowed to thaw in water at room temperature. Dissection tools included handmade thin wooden spatulas and jewelry forceps (Figure 2). The dissection was performed with the aid of the ENT microscope, using 2.4x to 25x magnification. Standard neuroanatomic texts as well as a textbook of bovine anatomy was used for the purpose of landmark identification and dissection1(Figure 3).

Figure 1: The fresh cadaveric cow brains were fixed in 10% formaldehyde for at least 40 days (1a). The arachnoid and vascular structures were carefully removed (1b).

Figure 2: Dissection tools are handmade thin wooden spatulas and jewelry forceps.
RESULTS

The dissection begins on the anterolateral surface of the bovine brain with peeling of the cortex from the frontal, parietal and temporal lobes respectively. Peeling away of the cerebral cortex reveals the arcuate fibers (Figure 4). These fibers connect the adjacent gyri of the brain. As in the human brain the arcuate fibers are short association fibers located just deep to the cerebral cortex. Dissection and removal of the arcuate fibers of the frontal, parietal and temporal lobes delineates the superior longitudinal fasciculus (Figure 5). In human brain superior longitudinal fasciculus surrounds the sylvian fissure, insula and connects the frontal, parietal, occipital, and temporal lobes, presents as a C-shape, and is located deep to the middle frontal gyrus, inferior parietal lobule, and middle temporal gyrus. Despite the lack of insula in bovine brain, the dissection showed that the superior longitudinal fasciculus connects the frontal, parietal, occipital and temporal lobes. Removal of the association fibers reveals the extreme capsule (Figure 6). Beneath the extreme capsule, the external capsule and claustrum are then approached (Figure 7). As in the human brain, deep to the external capsule and claustrum, occipitofrontal fasciculus, is subsequently seen. Due to absence of a true sylvian fissure, the uncinate fasciculus does not pass through the limen insula as in human brain. Similar to human brain, the external capsule consists mostly of deeper fibers of the occipitofrontal fasciculus. But the occipitofrontal and uncinate fasciculi are difficult to delineate from each other. Further dissection of the uncinate and occipitofrontal fasciculi reveals the gray matter of putamen (Figure 8). Due to intermix of striatopallidal fibers with the gray matter of putamen, the dissection of putamen feels semi spongy, somewhat difficult to dissect, impedes exposure of the globus pallidus and the internal capsule. (Figure 9). Once the globus pallidus is dissected, ventrally the anterior commissure becomes visible (Figure 10). This is the extent of white fiber tract dissection as our aim is to describe a basic fiber dissection model, to improve microsurgical skill and to enhance experience in this area before human brain is used.

Figure 3: Lateral view of the brain shows the lobes and the major fissures of the brain. Notice the temporal is located more ventrally and the lack of a lateral sulcus (pseudosylvian fissure).
Figure 4: Lateral view of the left cerebral hemisphere after peeling away of the cortex from the frontal and temporal lobes makes the arcuate fibers (af) visible (white arrows).

Figure 5: Following deeper dissection through arcuate fibers, the superior longitudinal fasciculus (slf) and corona radiata (cr) become evident (af) arcuate fiber

Figure 6: Removal of the association fibers reveals the extreme capsule (exc) and the occipitofrontal fasciculus (of).
**Figure 7:** Deep to the extreme capsule (exc), external capsule (ec) and claustrum (c) are revealed.

**Figure 8:** Further dissection of the external capsule reveals the putamen (p). (cr) corona radiata, (slf) superior longitudinal fasciculus

**Figure 9:** After dissecting the putamen away, the globus pallidus (gp) and the internal capsule (ic) are visible. (f) fornix (cr) corona radiata
Finding an alternative to practicing neurosurgical techniques, by both experienced neurosurgeons and those in training has gained significant interest in the recent past. Laboratory training models, particularly cow brains, have been described for practice of neurosurgical approaches\(^3,6\). Such models that are widely available and inexpensive are ideal for neurosurgery training programs. Historically brain white matter tract dissection precedes tissue examinations that use the microtome and histological sections. The earliest records go as far back as the 17th century with perhaps the most significant contribution having been made by Joseph Klingler, an anatomist in Basel, in early 20th century\(^4,5\). He employed dissection technique similar to those that preceded with the added step of freezing and thawing the fixed brain prior to dissection. This technique allowed for higher quality dissection, became popularized internationally and was identified by his name. In the recent years, technological developments, especially in microneurosurgery, increased interest in white matter fiber dissection among the neurosurgeons resulting in a wealth of information that addressed clinical and surgical challenge in this field\(^2,7,8,9\). These studies have allowed for improvement in neurosurgical skills, safer approaches and dissections of intrinsic brain pathologies. Consequentially white matter fiber dissection have become quite popular. Recently, very impressive and exciting studies, throw light on the complex anatomic features of these structures\(^7,8,9\). Our aim was to investigate if using the Klingler method, cow brain could serve as a useful and an inexpensive model for basic white matter fiber tract dissection. Even though there are significant difference between human and cow brain, some basic anatomic relationships are the same and the act of white matter dissection in formalin fixed cow brain is similar to the human brain. We thus recommend that cow brain white matter fiber dissection with Klingler's technique may be an alternative for those who need to become familiar with the basics of this technique as they begin their journey to approach the more complex white matter organization of the human brain.

**Conflict of interest**

None
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