Preparing low-cost cadaveric cross-sections for integrated teaching and learning of cross-sectional radiological anatomy and gross anatomy in medical education

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Running Title: Preparing low-cost cadaveric cross-sections

Abstract

The study of cross-sections in orthogonal planes lay a solid foundation for a 3-dimensional approach to learning anatomy and helps correlate with radiological cross-sectional images. We aimed to develop instructional material for such teaching/learning using a low-cost method for cross-sectioning. Cross-sections of preserved frozen cadavers were obtained analogous to CT imaging planes, and subsequently paired with corresponding radiological images for comparison. Hence, this cost-effective method can be used to develop resources for teaching both cross-sectional and radiological anatomy.

Keywords: medical education; anatomy; radiology; cross-sections; low cost

Integrating anatomy and radiology teaching in medical education has recently gained much attention and popularity, with medical educationists highlighting the benefits of such blended learning toward achieving higher learning outcomes in both subjects. Blending radiology with conventional anatomy teaching generates student interest in learning anatomy and highlights the clinical relevance of learning anatomy (1). Such integrated teaching curricula also prepare students for the knowledge and skills needed to interpret radiological images (1). Although competence in understanding basic radiological images is a current need for a medical practitioner it has been found in a US study that only 5% of the time span of the undergraduate teaching is allocated for radiology (2). Therefore, it is prudent to pursue methods for better teaching of radiology at the undergraduate level (1).

In addition to conventional cadaveric dissections, the study of cadaveric cross-sections in orthogonal planes helps lay a solid foundation for a 3-dimensional approach to learning the anatomy of internal structures and their relationships (3). Subsequent correlation of the gross anatomical cross-sections with radiological images such as computed tomograms (CT) and magnetic resonance images (MRI) enhances in-depth understanding of the radiological anatomy by escalating higher-order thinking skills (4).

With the introduction of cross-sectional anatomy in the basic science curricula, the University of Vermont, USA strived to develop cadaveric cross-section and corresponding radiological images-based teaching-learning materials since the 1940s (5). Hand saws were traditionally used to obtain human cross-sections using embalmed, frozen cadavers, which produced approximately 2.5 cm thick slices (5). With the recent advances of technology, laser-based devices have been introduced to obtain ultra-thin cross-sections of the human cadavers. The Visible Human Project is one such landmark study where thin cadaveric cross-sections (1 mm thin sections of a male and 0.33 mm thin sections of a female) were obtained in the axial plane and subsequently used to correlate with CT and MRI for educational and research purposes (6). However, these cross-sectioning techniques are expensive and are not affordable to many developing countries. Consequently, there is a ubiquitous need for the university system to embrace cost-effective mechanisms to produce instructional material based on cadaveric cross-sections which can be utilized to compare with the radiology sections. Therefore, the objective of this project was to develop a low-cost method for obtaining serial cross-sections of a human body in order to produce such instructional material.

This project was made up of three phases. In phase 1, a machine was developed in-house to obtain cadaveric cross-sections. It is made up of three components: a mounting table with a sliding mechanism, a shock-absorbing system, and a cutting system. Special features included a series of cutting blades for different tissue compositions, a system of rubber shock absorbers to dampen vibrations and minimize distortion of the cut surface of the tissues, a special lubricant to minimize cohesion of tissues during sectioning, and a guard fitted to the sliding machinery to ensure safety. In phase 2, the cadavers were preserved by injecting a Phenoxymethanol-based preservative solution into the femoral artery and were frozen at -20 0C for 24 hours before sectioning [the method of preservation is described elsewhere in detail (7)]. Cross-sections obtained analogously to CT imaging planes were carefully washed with running water at room temperature and displayed in 10% formaldehyde-filled Perspex boxes avoiding air trapping. In phase 3, the serial cross-sections were paired with the corresponding radiological images for comparison and correlation (Figure 1).

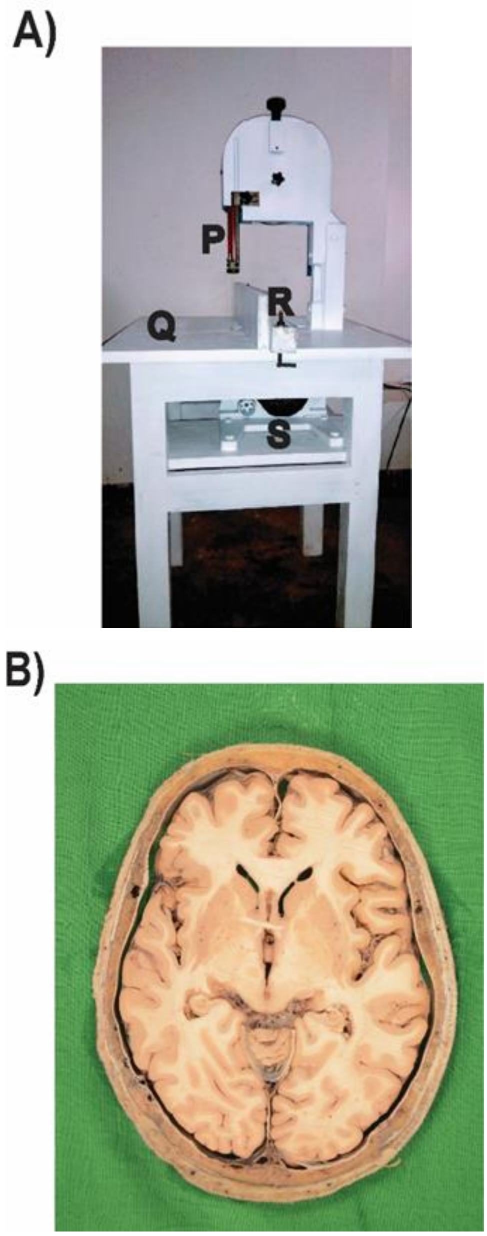

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Figure 1: Processing cadaveric cross-sections for educational material | A) The machine which was developed in-house to obtain cadaveric cross-sections B) An axial section of the brain at the level of the basal ganglia C) Educational material to compare and correlate cadaveric cross-sections with radiological images fit in a foldable container (left). This axial section is at the level of the hip joints. A line diagram is provided with the legends to facilitate self-learning (right).

This machine was built without the demand for complex technology; hence, it is possible for the majority developing countries to produce a similar instrument with existing resources and minimum technical expertise. The production cost of the developed machine was approximately 50 000 LKR (250 USD) and the subsequent preservation procedure was not demanding. Two point seven millimetre thin cross-sections could be obtained without distortion of the tissue architecture where structures as minute as 1-2 mm could be identified with their relations preserved (7, 8). There was remarkable colour preservation and the specimens could be easily compared with the corresponding radiological images for teaching-learning purposes. Therefore, this cost-effective and safe method can be used to develop resources to integrate teaching of radiology and anatomy. Further studies are required to explore the efficacy of such innovative material in understanding 3-dimensional and radiological anatomy in the basic sciences curricula.

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Conflicts of Interest

The authors declare that there are no conflicts of interest.

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