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A Low-Cost Mobile Training Model for Biportal Endoscopic Spinal Surgery

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ABSTRACT

AIM: To design a practical, low-cost, and freely mobile training model for biportal endoscopic spine surgery to improve the surgeons' abilities in basic endoscopic skills, including triangulation, two-dimensional visualization, and one-handed control of the instruments.

MATERIAL and METHODS: The training model involved three stages: triangulation, drilling, and punching. It was composed of sawbones covered by solid and impenetrable materials (a cardboard box was used), monitor (laptop or mobile phone), and hand tools, including an ear endoscope cameras for mobile phone and laptop, Dremel® style + rotary tool at 22000 rpm, Dremel® 2.0-mm diamond wheel point burr, Kerrison punch, No.11 blade, 18 G spinal needle, and mobile phone holder.

RESULTS: The model was set up with easily accessible materials and could be performed everywhere. It can also be used to perform laminotomy on sawbones using a high-speed diamond burr and Kerrison punch under a two-dimensional endoscopic view.

CONCLUSION: The training model can be useful in improving the endoscopic skills of all spine surgeons, particularly neurosurgeons and those who have little to no experience in endoscopic procedures. Additionally, it can provide familiarity on two-dimensional endoscopic views and triangulation.

KEYWORDS: Training, Endoscopic, Biportal spine surgery, Model

ABBREVIATION: BESS: Biportal endoscopic spinal surgery

INTRODUCTION

In recent years, several trials have been conducted to develop new endoscopic procedures in order to treat spinal pathologies (6,15). Endoscopic procedures have gained popularity and clinically been proven to be safe and efficient (17,18). Technological advancements have introduced better equipment and more reliable endoscopes, which have increased the quality of visualization. Thus, the indications for endoscopic procedures have also expanded (11). In the last decade, biportal endoscopic spinal surgery (BESS) was introduced as a minimally invasive spine surgery technique. During BESS, two portals are used. The first portal is used to introduce the endoscope and infuse the irrigation fluid. Using microsurgical tools, the procedure is carried out on the second portal. The second portal is also used to drain the irrigation fluid (16). It has been reported that BESS offers some advantages over the single-port approach, as it offers a variety of views, allowing for a better control and manipulation of endoscopes and instruments and providing easy access to the components of the spinal column (5).

Endoscopic spine surgery has a steep learning curve. Most surgeons, particularly un-experienced neurosurgeons who are new to endoscopic spine surgery, might face some challenges while performing endoscopic techniques. These challenges could include the difficulty in endoscopic visualization and triangulation, one-handed control of instruments, and loss of orientation of instruments due to bleeding. Overcoming these problems require improved skills in endoscopic surgery and a familiarity of working with a two-dimensional view (4,9,13).

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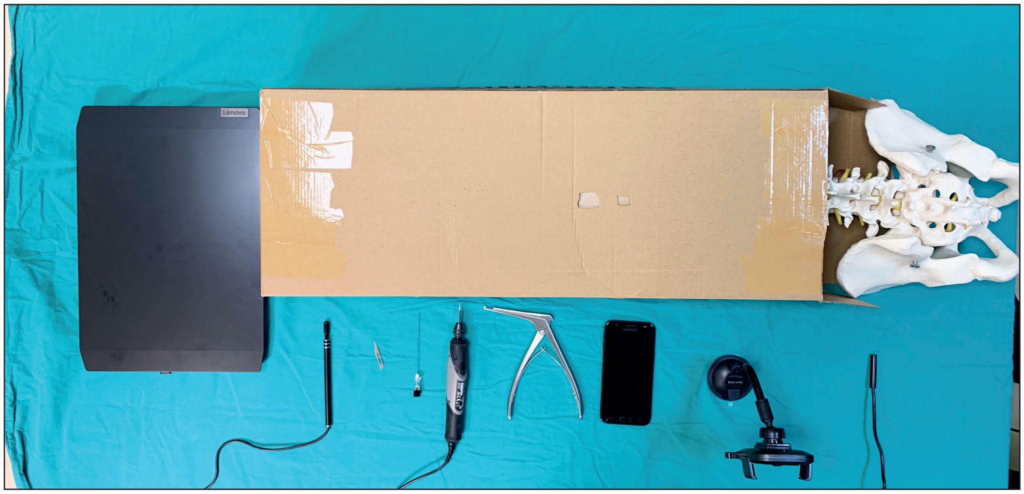

Figure 1: Components of the unilateral biportal endoscopic (UBE) model. Spine sawbone, cardboard box, laptop, ear endoscope camera compatible with mobile phones, mobile phone holder, mobile phone, Kerrison punch, Dremel® stylo, spinal needle, No. 11 blade, and ear endoscope camera compatible with laptops.

Figure 2: The level of the portals was determined by placing an 18 G spinal needle thorough the cardboard box approximately to the spinolaminar junction of the chosen surgical level before closing the cardboard cover.

Several techniques have been described in literature about hands-on training courses on cadaveric or animal models, model-based practice, and virtual simulations to improve the surgeons' endoscopic skills (1,10,12). However, these approaches have some limitations, particularly the high cost of cadaveric and animal models and virtual simulations. In this study, a practical, low-cost, and freely mobile training model for BESS was developed to improve the surgeons' abilities in basic endoscopic skills, including triangulation, two-dimensional visualization, and one-handed control of instruments.

MATERIAL and METHODS

This study did not involve any human or animal participants. Therefore ethics committee approval was not needed.

Our BESS model involved three stages: triangulation, drilling, and punching. The training model was composed of sawbones covered by solid and impenetrable materials (a cardboard box was used), monitor (laptop or mobile phone), and hand tools, including ear endoscope cameras compatible with a mobile phone or laptop, Dremel® stylo + rotary tool at 22000 rpm, Dremel® 2.0-mm diamond wheel point burr, Kerrison punch, No.11 blade, 18 G spinal needle, and mobile phone holder (Figure 1).

A No. 11 blade was used to create entrance portals on the cardboard box, and simulation drilling and punching were performed through these portals. A cardboard box was used for this model because it is inexpensive and readily accessible.

A spine sawbone was placed in the cardboard box, which was then closed completely to avoid the entry of light into the training area. The endoscope itself was used as a light source. A side of the training area was selected based on the dominant hand of the trainee. The trainee held the endoscope with their non-dominant hand and the other tools with their dominant hand. The level of the ports was determined by placing an 18 G spinal needle thorough the cardboard box approximately to the spinolaminar junction of the chosen surgical level before closing the cover (Figure 2).

Next, we marked the portals which were three centimeters apart and placed 1.5 cm caudally and 1.5 cranially of the spinal needle (Figure 3A). We opened the portals that centered the points and placed the tools thorough the portals (Figure 3B).

Following the setup using laptop or mobile phone we achieved the anatomical orientation and triangulation, started the procedure by drilling the lamina (which started from spino-laminar junction of the cranial level) using the high-speed drill under laptop view (Figure 4A) and completed the laminotomy by exposing the dural sac using the Kerrison punch (Figure 4B). Additionally, same procedures could be done with mobile phone using USB Camera® application (Shenzhen wxl Technology limit, Shenzhen, China) (Figure 5A, B).

RESULTS

The BESS training model was set up using easily accessible materials on a very low budget. In addition, it is possible to perform on our model everywhere, even in out-patient clinics, office, or at home. Our model gave a chance to perform laminotomy on sawbones using a high-speed diamond burr and Kerrison punch under a two-dimensional endoscopic view.

DISCUSSION

Although endoscopic spinal surgery has increasingly gained popularity, an inadequate training of surgeons is still a major cause of complications (3). Surgeons, especially neurosurgeons who lack endoscopic spinal surgery experience, face challenges while performing these procedures because they are unfamiliar with the two-dimensional view, and they also lack adequate endoscopic spine surgical training on real patients.

Animal and cadaveric models, 3D-printed models, virtual reality devices, and sawbones have been described as surgical training models. Animal models appear to be convenient for surgical training; however, anatomical differences between animals and humans and possible ethical issues that may arise are the most important obstacles in their use (7). Cadaveric models are also a suitable option for training, but there are difficulties with this option as well, including their high costs, accessibility and availability problems, and special requirements, such as specific environments needed to carry out the training (8). Virtual simulations and 3D-printed models are also useful for training, but the need for extra equipment limits their widespread use (10,14). Alternatively, sawbones are mobile, do not require any extra equipment, and are easy to make and access. For these reasons, using this training model makes it possible to provide BESS training anytime and anywhere.

Other neuroendoscopic training models for endonasal and intracranial approaches have been previously described in

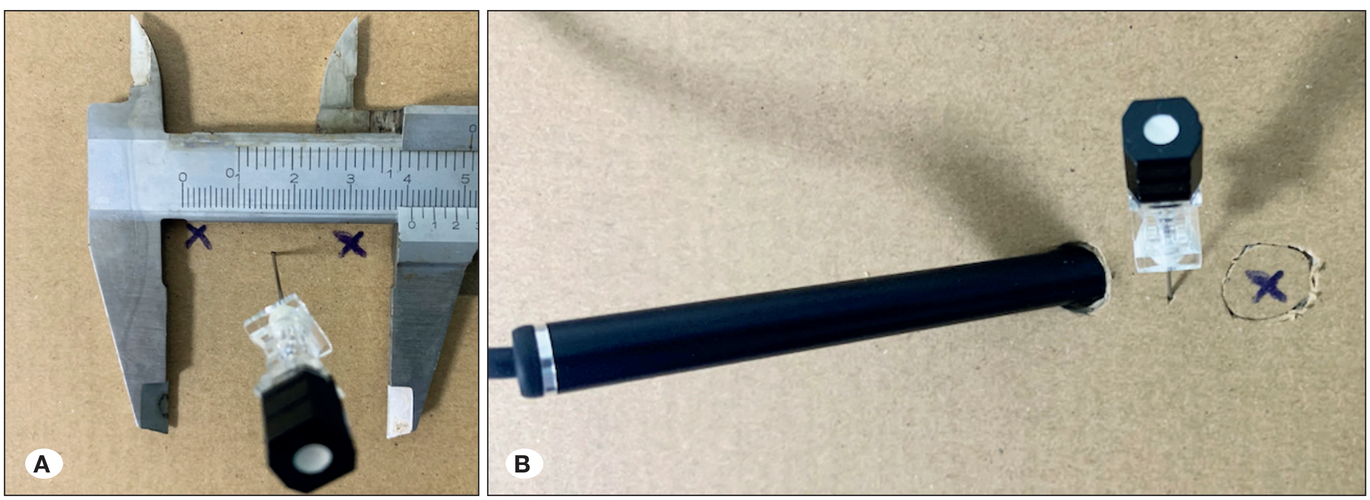

Figure 3: A) Determination of the portals placed 1.5 cm caudally and 1.5 cm cranially of the spinal needle. **B)** Opening of portals that centered the points and placement of an endoscope.

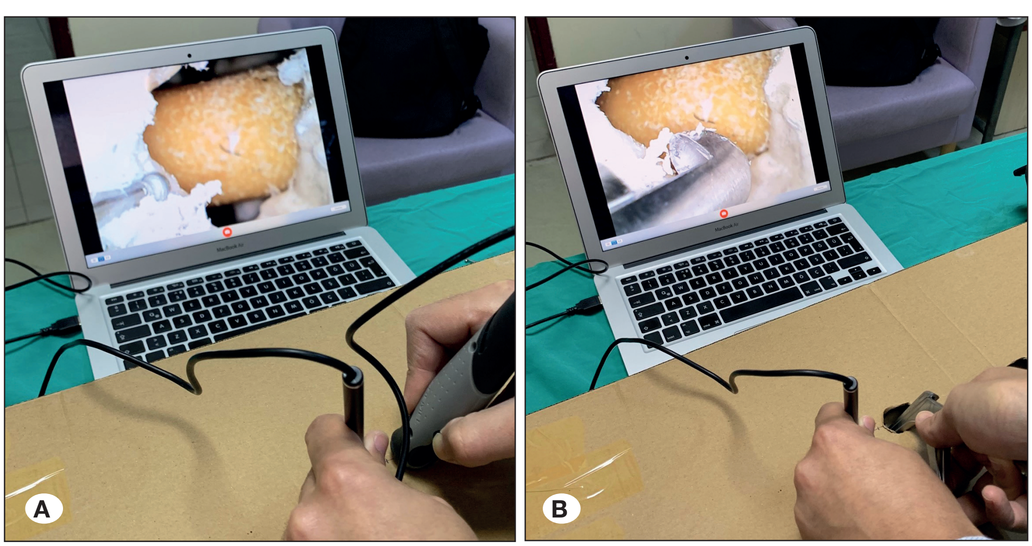

Figure 4: Laminotomy was performed using a high-speed burr **(A)** and Kerrison punch **(B)**.

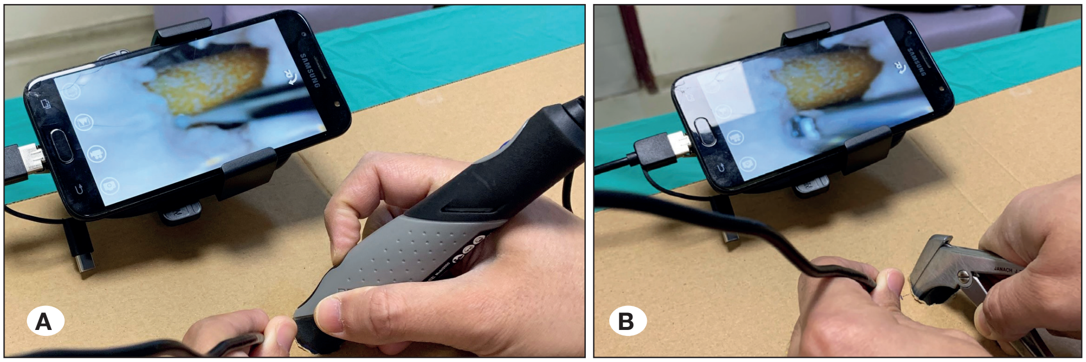

Figure 5: Laminotomy was performed using a high-speed burr **(A)**, and Kerrison punch **(B)**.

literature (19). Regarding endoscopic spine surgery, Amato et al. reported an animal model for interlaminar monoportal spinal procedures (2). To the best of our knowledge, there are no studies on BESS training models. Therefore, a practical BESS training model was developed to assist in improving the surgeons' endoscopic skills.

Starting from their residency training, neurosurgeons gain familiarity with the three-dimensional view under a microscope. Thus, the use of an endoscope in spinal surgery with a two-handed technique may pose as a challenge for spinal surgeons, especially neurosurgeons (4). Since orthopedic surgeons perform various arthroscopic procedures on various joints, it can be concluded that they probably have more experience in using endoscopes during surgeries than neurosurgeons who have limited chances in using endoscopic equipment during their residencies (16). This might lead to unfamiliarity with endoscopic equipment and inexperience in choosing the most appropriate surgical approach. BESS instruments include the same arthroscopic equipment used in knee, shoulder, ankle, and wrist arthroscopy and open spinal surgery equipment, such as Kerrison punch and spinal osteotome (11). Therefore, because an orthopedic spinal surgeon's adaptation to BESS might be easier than that of a neurosurgeon, we believe that our model may be more beneficial to neurosurgeons.

Our BESS training model is inexpensive, portable, as it can be used anywhere, and requires only basic BESS equipment. It can help surgeons who have limited or no experience with endoscopic spinal procedures improve their skills by performing laminotomy on sawbones using a high-speed diamond burr and Kerrison punch under a two-dimensional endoscopic view.

The major limitation of our BESS model is the fact that it does not contain soft tissues, including the paraspinal muscles, ligamentum flavum, epidural vessels, and disks, where surgeons may have trouble dissecting through in an actual BESS surgery. Therefore, this model can only be accepted as a basic training model to improve the basic endoscopic skills of surgeons who have little to no experience in endoscopic spinal procedures.

CONCLUSION

In conclusion, we believe that the use of this training model can be beneficial for all spine surgeons, particularly neurosurgeons and those who have little to no experience in endoscopic procedures. While surgeons should keep in mind that endoscopic spinal surgery has a steep learning curve, this training model was designed to help improve the surgeons' endoscopic skills and provide familiarity on two-dimensional endoscopic views and triangulation in BESS surgery.

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AUTHORSHIP CONTRIBUTION

Study conception and design: ES
Data collection: ES
Analysis and interpretation of results: ES, HYE
Draft manuscript preparation: ES, HYE
Critical revision of the article: HYE
All authors (ES, HYE) reviewed the results and approved the final version of the manuscript.

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