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The Educational Usefulness of a Cranial Nerve Nuclei Model for First-Year Dentistry Students

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Normal anatomy classes are a major element of the curriculum in dentistry studies. The anatomy of cranial nerves is one of the aspects of particular importance for future dentists. The transfer of knowledge regarding the anatomy and topography of cranial nerve nuclei is very difficult since the structures cannot be presented using an anatomical specimen. An anatomical brain stem model was developed by our team as a teaching aid for students studying the anatomy of cranial nerve nuclei. A survey to evaluate the usefulness of this model was conducted in a group of 100 first-year dentistry students. As shown by the study, classic anatomical models may provide important pillars when teaching anatomy to dentistry students.

Keywords: anatomy education, anatomical model, medical students.

Introduction

As part of normal anatomy classes taught to dentistry students, much attention is paid to the anatomy of cranial nerves. Knowledge of the structure and topography of cranial nerves is useful in the everyday practice of general dentistry practitioners as well as maxillofacial surgeons (Treasure et al., 2013). The process of learning the topography of cranial nerve nuclei is based on memorization tools alone. No teaching aids other than figures in textbooks or atlases are available to facilitate the acquisition of knowledge on this important subject. Consequently, we created a model allowing students to visualize the cranial nerve nuclei in all its dimensions.

The educational use of anatomical models dates back to centuries ago. The earliest known model used for educational purposes was made of wax by Gaetano Giuliano Zumbo in the 17th century (Haviland and Parish, 1970; Maraldi et al., 2000). Today, models are made on a mass scale by no particular authors. State-of-the-art technologies can contribute to the increased precision of models, e.g. thanks to the use of 3D printers and

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video-instruction systems. Full virtual reality models are also feasible (McMenamin et al., 2014; Heather, 1998; Nguyen and Wilson, 2009). Thanks to the widespread use of plastination techniques, anatomical models are commonly replaced by plastinated specimens (Latorre, 2001). Unfortunately, proprietary models are increasingly often used as museum exhibits only. As shown by this article, hand-made anatomical models still have an enormous educational potential.

Research Methodology

A classic, hand-made anatomical model of the brain stem was used in the study. The model was designed on the basis of textbooks and anatomical models used by students. The model, 170 cm tall and 100 cm wide (the average scale of 20:1), was prepared using standard sculpting techniques. Each nucleus was color coded in red (motor nuclei), blue (sensory nuclei), or black (parasympathetic nuclei) and illuminated using a light emitting diode. A total of 24 switches corresponding to individual nuclei were placed on a dashboard and grouped in accordance with their function (motor, sensory, autonomous) or in accordance with individual cranial nerves (Figure 1).

The study population consisted of all first year dentistry students (n=100, divided into 8 student groups) who attended regular anatomy classes in 2019. Each student group as a whole was randomly allocated either to a control or the intervention. Participants were subjected to a previously unannounced test of knowledge on cranial nerves. The test consisted of 10 questions relating to theoretical knowledge and 10 questions relating to the topography of cranial nerves. The maximum possible score was 100. The first group (C – control group) took the test following a 15-minute period of study using textbooks and atlases. The other group (M – model group) was given 15 minutes for individual work with the model along with the possibility of studying with books and atlases. At the end of the test, students reported their age and gender, provided an assessment of individual questions in terms of difficulty and evaluated the usefulness of the model using a 0 to 5 scale. The values of the quantitative variables were presented as arithmetic means and standard deviations. Due to the non-normal distribution of the values in individual groups (as determined by the Shapiro-Wilk test and the visual evaluation of histograms), the non-parametric Mann-Whitney U test was used for the comparative analysis. The statistical significance level was established at $p<0.05$. Calculations were done using the STATISTICA 13.1 PL (TIBCO Software, USA) software package.

Research Results

The study group consisted of 100 students (21 M, 79 F). The mean score in group M was 47 points whereas the mean score in group C was 28 points ($p<0.05$). The mean score achieved by the students for the theoretical questions was 26 points. The results were much worse when it came to questions regarding topographical relationships (12 points). The difference was statistically significant. The results in group M were found to be better than those in group C for both parts of the test: 28 points vs. 19 points for the theory questions and 23 points vs. 5 points for the topography questions, respectively ($p<0.05$). The average score of male students was 36 points. Students from group M achieved slightly better results than students from group C (39 vs. 32 points; $p>0.05$). The average score of male students was 38 points. There was a significant difference between groups M and C (50 vs. 27 points; p>0.05). Student-reported problems were about five times more common for topography-related questions compared to theory-related questions (27 vs. 4). In the students' assessment of usefulness, the model received a grade of 4.

Discussion

Each memory process consists of three stages: i) encoding, ii) storage, and iii) retrieval. In this process, the brain "pins" new information to that which is already stored. When reading a text consisting of letters, students combine these letters to form words which are then used for the retrieval of images known from real life (Dudley, 1998). The results achieved by group M students were better because simultaneously to the process of encoding the knowledge obtained from books, they associated the new information with that obtained when observing and touching individual elements of the model. In this manner, the names of individual nerves were associated with particular shapes, colors and switch labels on the models. In addition, the model proved most useful in relation to topography-related questions, which correlated with the results of the study assessing the use of the model when teaching medical students (Komarnitki et al., 2019).

The differences in the obtained results between groups C and M were much more pronounced than those between both genders. Slightly better test results were obtained by female students (p>0.05). These findings were in line with those obtained in another study conducted of a group of medical students using the cranial nerve nuclei model (Komarnitki et al., 2019). The best results in groups M and C were recorded for questions 1a (theoretical question regarding oculomotor nerve nuclei) and 3a (theoretical question regarding trigeminal nerve nuclei). The worst results in groups M and C were recorded for questions 1b (topographical question regarding oculomotor nerve nuclei), 2b (topographical question regarding the trochlear nerve nucleus), 3b (topographical question regarding trigeminal nerve nuclei), 4a (theoretical question regarding abducens nerve nuclei), 4b (topographical question regarding abducens nerve nuclei), 5b (topographical question regarding facial nerve nuclei), 7b (topographical question regarding glossopharyngeal nerve nuclei), and 9b (topographical question regarding accessory nerve nuclei) (Figure 2). As can be easily noticed, most questions posing problems to the students concerned the topography of the nuclei. This might be due to the complex location of these structures. The percentage of correct answers to these questions was found to be significantly higher in group M compared to group C (Figure 2), suggesting that the model was helpful in memorizing the complex topographical relationships between the anatomical structures. In previous studies on the educational usefulness of the same model for medical students, statistically significant differences between groups M and C were found for questions regarding the location of the glossopharyngeal nerve ($p = 0.03$), abducens nerve ($p = 0.018$), hypoglossal nerve ($p < 0.001$), and accessory nerve ($p < 0.001$) (Komarnitki et al., 2019). Students who approached the test following an earlier educational session with the model provided better answers to both theoretical and topographical questions ($p < 0.001$). They also considered the test to be less difficult ($p = 0.01$).

According to Gardner's theory of multiple intelligences, each student perceives a problem in the context of their dominant abilities. In our opinion, among other factors, the results achieved by students in group M were better that those in group C due to the fact that the model facilitated the activation of as many as 4 out of 8 intelligences. The anatomical names of the nuclei presented on the model dashboard may have contributed to better memorization by students with dominant verbal-linguistic abilities. The fact that the dashboard switches were ordered in three rows in accordance with their type (10 motor nerves, 10 sensory nerves, 4 parasympathetic nerves) may facilitate the memorization of nerve types by individuals with logical-mathematical intelligence. The memorization of the topography of individual nuclei within the brain stem and the color-based identification thereof could be used for the acquisition of knowledge by students with visual-spatial intelligence (Gardner, 2011).

As shown by the study, classic anatomical models may provide important pillars when teaching anatomy to dentistry students.

Conclusions

The study demonstrated the usefulness of an anatomical model of cranial nerve nuclei, as it activates numerous capabilities required when mastering the study material. This classic anatomical model is useful when solving theoretical as well as topographical problems. As shown by the study, the presented model of cranial nerve nuclei can be effectively used when teaching anatomy to dentistry students. Models of this type may also prove useful to students of other specialties, such as psychology and speech therapy.

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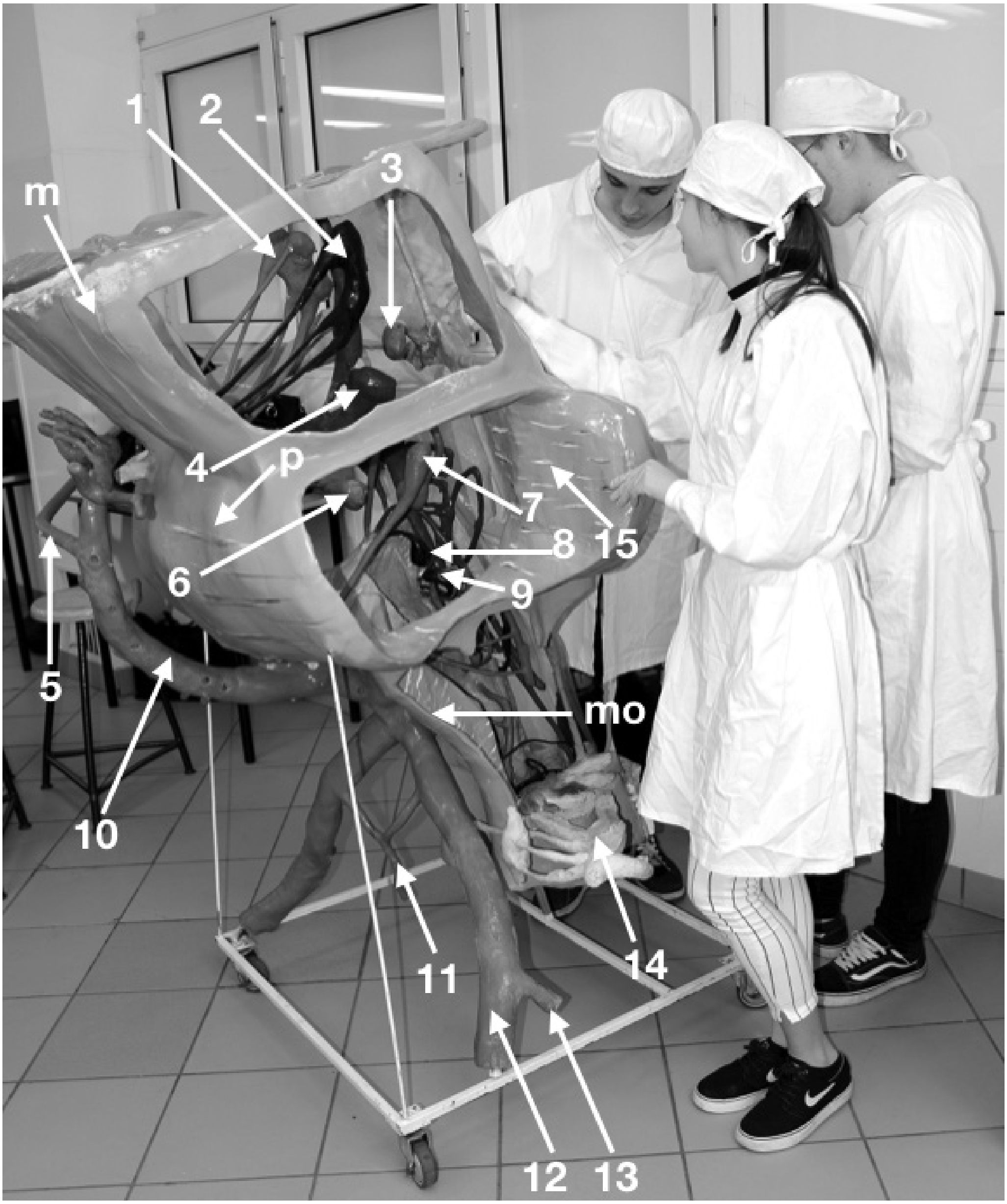
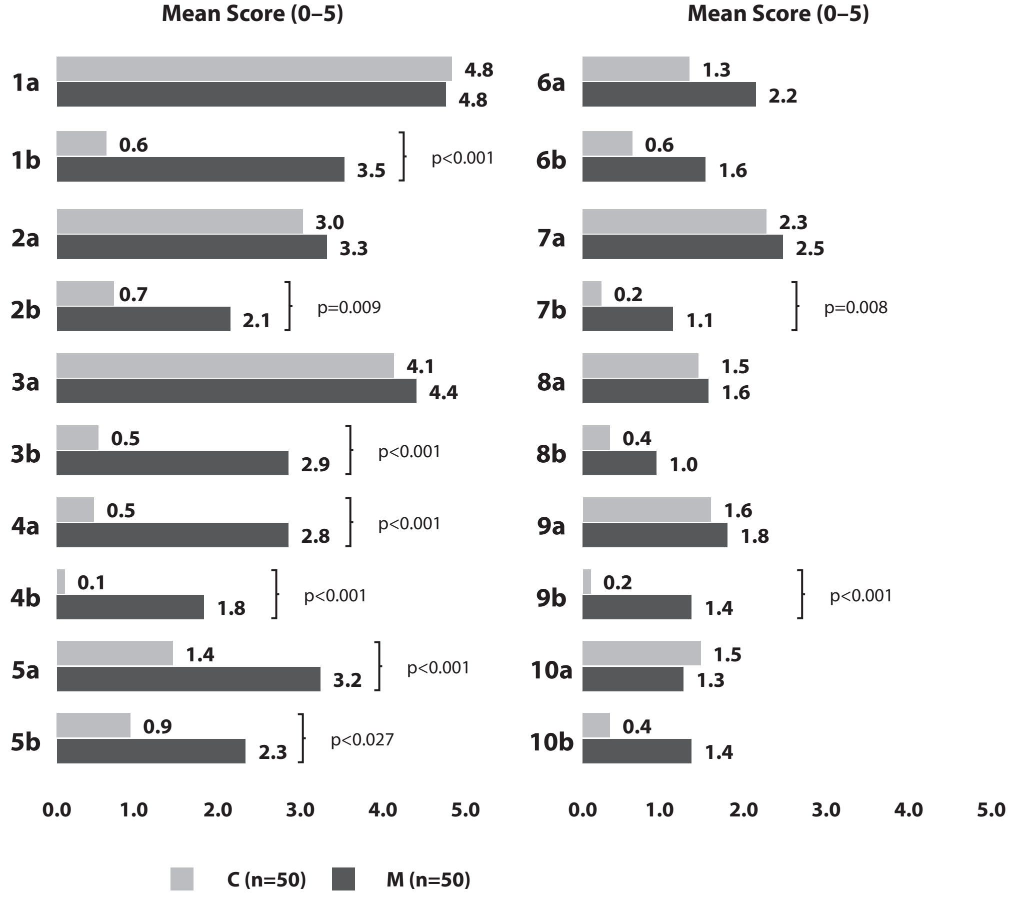
Figure 1. Cranial nerve nuclei model during the lesson. A view from the left



Legend:

m – midbrain, p – pons, mo – medulla oblongata, 1 – central caudate nucleus of oculomotor nerve, 2 – Edinger-Westphal nucleus of oculomotor nerve, 3 – nucleus of trochlear nerve, 4 – principal sensory nucleus of trigeminal nerve, 5 – superior cerebellar artery, 6 – motor nucleus of trigeminal nerve, 7 – abducens nucleus, 8 – superior salivatory nucleus, 9 – inferior salivatory nucleus, 10 – basilar artery, 11 – anterior spinal artery, 12 – vertebral artery, 13 – posterior inferior cerebellar artery, 14 – spinal nerve, 15 – middle cerebellar peduncle

Figure 2. Comparison of results obtained for individual questions in different student groups



Source: authors' own research.