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Radiological anatomy as an alternative approach in anatomy teaching. Perception and performance of medical students

Radiological anatomy as an alternative approach in anatomy teaching. Perception and performance of medical students

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Abstract

Introduction: In resource-deprived countries, dissection as means of teaching anatomy is often not feasible due to limited availability of bodies, high cost, and safety risks. In Nicaragua, anatomy and radiology education is in an independent format in the medical curriculum.

Objective: This paper aims to explore the impact (performance and perceptions) of the use of radiological images in teaching anatomy in medical students from a resources-deprived country.

Method: An extracurricular course of radiologic anatomy of the trunk was implemented to third (n=87) and sixth (n=67) year medical students. Pre-and post-test and a post-course survey were applied. Mean, median, and SD were calculated, with a confidence interval level of 95%.

Results: Perceptions from both groups were similar. Re-garding radiological techniques: CT (82.8% junior and 94% senior students) was the most helpful, and ultrasound was the least (49.4% junior and 67.2% senior). Didactic resource acceptance: study guide (73.6% junior and 82.1% senior) and digital-interactive atlas (69% junior and 80.6% senior) got the highest score, while printed books (36.8% junior and 59.7% senior) got the lowest score. The pre-test scores were similar in both groups (mean of correct answer 7.98 junior and 8.22 senior). The mean of correct answers increased in both groups in the post-test: 32.03 for junior and 32.82 for senior students (p=0.000).

Conclusions: Integration of radiology and anatomy positively impacts medical students; it should be implemented through a self-directed learning approach and considered complementary in the medical curriculum as a good alter-

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native for teaching anatomy in countries where dissection is not feasible.

Keywords: Teaching anatomy; radiological anatomy; pre and post-test; anatomy and radiology integration.

Anatomía radiológica: alternativa en la enseñanza de anatomía. Percepción y desempeño de estudiantes de medicina Resumen

Introducción: En países con escasos recursos, la disección como medio para enseñar anatomía no es factible a menudo, debido a la disponibilidad limitada de cuerpos, alto costo y riesgos de seguridad. En Nicaragua, la anatomía y radiología se estudia de forma independiente.
Objetivo: El objetivo del estudio es explorar el impacto (desempeño y percepciones) del uso de imágenes radiológicas en la enseñanza de anatomía en estudiantes de medicina de un país con bajos recursos.
Método: Se implementó un curso extraescolar de anatomía radiológica a estudiantes de medicina de tercer (n=87) y sexto (n=67) año. Se aplicó una pre/posprueba y una encuesta posterior al curso. Se calcularon la media, mediana y desviación estándar, con un nivel de intervalo de confianza del 95%.
Resultados: Las percepciones de ambos grupos fueron similares. Relacionado a las técnicas radiológicas: TC (82.8% junior y 94% senior) fue la más útil; y la ecografía la menos (49.4% junior y 67.2% senior). Aceptación de recursos didácticos: guía de estudio (73.6% junior y 82.1% senior) y atlas digital interactivo (69% junior y 80.6% senior) obtuvieron la puntuación más alta; mientras que los libros impresos (36.8% junior y 59.7% senior) obtuvieron la puntuación más baja. Los puntajes previos a la prueba fueron similares en ambos grupos (media de respuesta correcta 7.98 junior y 8.22 senior). En la posprueba, la media de aciertos aumentó en ambos grupos: 32.03 para junior y 32.82 para senior (p=0.000).
Conclusiones: La integración de la radiología y la anatomía tiene un impacto positivo en los estudiantes de medicina, debe implementarse a través de un enfoque de aprendizaje autodirigido, y considerarse complementaria en el plan de estudios médico como una buena alternativa para enseñar anatomía en países donde la disección no es factible.

Palabras clave: Enseñanza de anatomía; anatomía radiológica; pre y posprueba; integración de anatomía y radiología.

INTRODUCTION

Dissection has been the primary anatomy teaching approach for a long time; its didactic benefits are well known, i.e., understanding the 3-D of the human body and developing the haptic skill. Nevertheless, due to its limited availability, high cost, and safety risk, this method is operationally, technically, and economically unfeasible for resource-deprived countries[1].

Among the biomedical science courses, gross anatomy represents a unique opportunity to incorporate new information and communication technologies because of its visual nature[1,2]. Various radiological images, such as X-rays, ultrasound (USG), computer tomography (CT), magnetic resonance image (MRI), and positron emission tomography (PET), provide information regarding the morphology, function, and metabolism of the human body[3].

The benefits of implementing X-ray, USG, CT, and MR imaging in studying anatomy in medical schools have been well reported in recent years. Among the benefits reported are a three-dimensional exploration of anatomical relationships, in vivo visualization of morpho-functional, manipulation of images for a detailed study of specific organs, and ease in interpreting these images in clinical practice[4-15].

After the cadaver radiography was implemented as a tool in the teaching of anatomy, the complementary use of radiology in anatomy education has grown, this supported by the greater access to im-

ages due to their digitization, consequently that X-ray, CT, USG, and MRI images are now a common platform for learning anatomy in medical schools[2].

Although medical students do not become radiologists, regardless of the type of health care they provide in the future (be it primary or specialized care), they need to develop fundamental knowledge in interpreting radiological images to understand the consultation reports of radiologists[16].

Regardless of their preferred medical specialty, medical students must develop the correct interpretation of imaging and get familiar with the data presented; this skill will help them overcome potential deficiencies in their future clinical practices[17].

The integration of radiological images in anatomy teaching is beneficial because, besides stimulating and reinforcing anatomy and its understanding and clinical application, this synergy leads to better retention of both disciplines (anatomy and radiology)[17].

Curricula, which integrates medical imaging with dissection/prosection and online multimedia materials, has improved students' performance and interest in anatomy and radiology[18].

In Nicaragua, anatomy education in most medical schools is provided through lectures and practical classes, using prosection, models, textbooks, and banners. Radiology education is traditional through lectures and uses mainly X-ray films. Because of economic cost, access to other radiological imaging methods, like USG, TC, or MRI, is limited. Currently, in Nicaragua, anatomy, and radiology education are addressed in an independent format. Local outcomes from surveys, OSCE (objective structured clinical exam), and OSPE (objective structured practical exam), implemented as part of the regular assessment at the end of academic courses of anatomy and medical skills components, have reflected student difficulties regarding interpreting imaging and correlating anatomical regions due to lack of appropriate cadavers for teaching.

This paper aims to explore imaging's impact (performance and perceptions) in teaching anatomy in medical students from deprived-resources countries. We investigated the effectiveness of radiological anatomy in anatomy teaching, comparing junior and senior students' performance in pre-test and post-test and collecting their opinions about the usefulness of imaging through a survey. We expected that senior students have better performance and more positive perceptions than junior students because of their years of experience in medical training.

METHOD
Study design
The study design was a quantitative research approach, specifically a group comparison cross-sectional survey design[19].

Context
An extracurricular and accessible course on the radiological anatomy of the trunk was designed and elaborated by the primary researcher and her assistant students, using a range of didactic resources.

The course was face-to-face with a methodology that promoted active and collaborative learning through the following didactic activities: lectures, practical classes, and plenary sessions. It lasted six weeks, in which the student spent approximately 5 hours a week. Participants had online access to teaching resources (atlases, videos, study guides, and conference presentations).

Didactic videos on anatomy and radiological anatomy and dynamic interactive electronic atlases (using X-ray, USG, and CT images, without pathology) were made. The interactive atlas has the following features: descriptive text, a label of anatomical structures, change of view (window), measure tools, image transformation (rotation, zoom), search button, mobility through directional arrows.

Another didactic resource was the practical class guide, which contained a checklist of anatomical structures that the students had to identify in the atlas. The radiological images used were supplied by the University medical center of Utrecht (UMCU) in DICOM format.

We applied the same practical exam of 50 questions before and after the course (pre and post-test study). The practical exam contained three questions about generalities of anatomy, seven questions about generalizations of medical imaging, and 40 questions about the terminology of anatomical structures. Also, we applied a survey at the end of the course that addressed the following aspects:

usefulness of the imaging technique (X-ray, USG, CT, MRI), usefulness and quality of the didactic resources (atlas, knowledge-based videos, printed books, study guides and films of radiological images), and usefulness and quality of each interactive atlas's feature (descriptive text, label, window, measure tools, image transformation, search button, directional arrows).

The team research elaborated survey and test questions, and then they were validated by the staff teachers.

Sample
Our sample was medical students at the National autonomous university of Leon, Nicaragua (UNAN-Leon), which participated voluntarily in the trunk's extracurricular course of radiologic anatomy. Students from the third (216 students) and sixth (159 students) year of medicine were invited to participate in the class.

Third-year students (junior) have studied the anatomy of the digestive, respiratory and cardiovascular systems, which they learned during the second year of their career. However, they have little or null experience with radiological images. Sixth-year students (senior) have completed their studies about all anatomy systems and are more familiar with radiological images (especially X-rays) because of their clinical practice.

Analysis
The respective academic year was crossed with the variables studied (number of correct answers, perceptions about usefulness, and quality of the didactic resources). Also, we compared the outcomes of the pre and post-test of both groups (senior and junior students).

Through a linear regression, Pearson's chi-square test was used for the dichotomous variables and the independent sample' t-student test for continuous variables, considering a value of $p < 0.005$. Mean, median, standard deviation (SD), and p-value were calculated, with a confidence interval level of 95%.

Ethical considerations
Informed consent from participants was requested, and it was explained that their participation in the study was completely voluntary and anonymous. The faculty of medical sciences of the National autonomous university of Leon, Nicaragua, approved this study.

RESULTS
A total of 154 students participated in the study, 87 (56.4 %) students of the third year and 67 (43.5%) students of the sixth year of medicine. The predominant age range was 20 – 25 years old (60.4%), and most students were female (51.9%).

Comparison of performance in pre-Test and post-Test of both third and sixth year of med students
The performance (number of the correct answer) of both groups were very similar. In the pre-test (50 questions in total), both groups got the same minimum (2 correct answers) and almost the same maximum (18 correct answers for the third year and 17 correct answers for the sixth year). The mean was very similar, 7.98 for the third year and 8.22 for the sixth year.

In the post-test (50 questions in total) in both groups, there was an improvement in the test results: the minimum was 12 correct answers for the third year and 20 for the sixth year, the maximum was 45 correct answers for the third year, and 47 for the sixth year. The mean also increased in both groups: 32.03 for the third year and 32.82 for the sixth year. In both groups, third and sixth year, there was statistical significance ($p \leq 0.005$) **(table 1)**.

Perceptions of students about usefulness of diverse didactic resources used during a radiologic anatomy course
To measure the usefulness of diverse didactic resources in anatomy teaching, we request students to rate on a scale from 1 to 5 points, with 1 being the lowest score and five being the highest. Concerning the use of radiological imaging in anatomy teaching, the four methods (X-ray, USG, CT, and MRI) in general received a high frequency of 5 points. Students in both groups (third and sixth year) considered that CT (82.8% for the third year and 94% for the sixth year) and X-ray (66.7% for the third year and 77.6% for the third year) are very useful in anatomy teach-

Table 1. Comparison of performance (correct answers) in pre-and post-test. Pearson´s chi-squared test

	Third-year		Sixth year	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
	n=87		**n=67**	
Minimal	2	12	2	20
Maximum	18	45	17	47
Mean	7.98	32.03	8.22	32.82
Standard deviation	3.94	6.12	3.21	5.77
p	0.000		0.000	

Table 2. Frequency of highest score (5) of the usefulness of radiological imaging in anatomy teaching

	Third-year		Sixth year	
Radiological technique	**n=87**		**n=67**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
X-ray	58	66.7%	52	77.6%
Ultrasound	43	49.4%	45	67.2%
CT	72	82.8%	63	94%
MRI	47	54%	47	70.1%

Table 3. Frequency of highest score (5) of the usefulness of didactic resources

	Third-year		Sixth year	
Didactic resources	**n=87**		**n=67**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Digital interactive atlas	60	69%	54	(80.6%)
Didactic videos	48	55.2%	49	(73.1%)
Study guide	64	73.6%	55	(82.1%)
Printed books	32	36.8%	40	(59.7%)
Film of radiological images	38	43.7%	45	(67.2%)

ing. The technique which obtained the lowest score in both groups was ultrasound (49.4% for the third year and 67.2% for the sixth year). The four methods received a higher valuation from the sixth-year group than the third-year group, with a difference between the two appraisals from 8 to 19% **(table 2)**.

About the usefulness of different didactic resources used during radiological anatomy, both groups scored high on the study guide (73.6% for the third year and 82.1% for the sixth year) and on the digital interactive atlas (69% for the third year and 80.6% for the sixth year). It should be noted that printed books obtained a low frequency of usage in both groups (36.8% for the third year and 59.7% for the sixth year). All didactic resources received higher scores from the sixth-year group than the third-year group, with a difference between the two valuations from 9 to 24% **(table 3)**.

All the components had high scores in both groups (third and sixth year) about the features of the digital interactive atlases of radiological anatomy. But the highest score was for: change of view/window (95.5% for the sixth year and 86.2% for the third year), structure search button (95.5% for the sixth year and 88.5% for the third year), and directional arrows (95.6% for the sixth year and 82.8% for the third year). The feature with the lowest score in both groups was the measure tools (59.8% for the third year and 71.6% for the sixth year). It is worth noting that the sixth-year group gave higher scores in all

Table 4. Frequency of highest score (5) of the usefulness of the features of the Interactive digital atlases of radiological anatomy

Interactive atlas features	Third-year n=87		Sixth year n=67		p
	Frequency	Percentage	Frequency	Percentage	
Descriptive text	53	60.9%	57	85.1%	0.007
Label of anatomical structures	56	64.4%	52	77.6%	0.280
Change of view (window)	75	86.2%	64	95.5%	0.115
Transformation of images (rotation, zoom)	55	63.2%	53	79.1%	0.111
Measure tools	52	59.8%	48	71.6%	0.541
Structure search button	77	88.5%	64	95.5%	0.209
Directional arrows	72	82.8%	64	95.5%	0.085

Table 5. Opinions of med students on how radiological anatomy courses should be delivered concerning the curriculum of medicine

Type of course	Third-year n=87		Sixth year n=67	
	Frequency	Percentage	Frequency	Percentage
Compulsory	49	56.3%	52	77.6%
Elective	27	31%	9	13.4%
Extracurricular	7	8%	1	1.5%
Lost data	4	4.6%	5	7.5%
p	0.004			

features than the third-year group, with a difference between the two appreciations from 8 to 22%; however, there was no statistical significance (p ≥ 0.005) **(table 4)**.

The course of radiological anatomy in the medical curriculum

In our area of study (UNAN-Leon), radiologic anatomy teaching is not implemented. Regarding the learning of radiological anatomy course in the medical curriculum, the majority stated that it should be compulsory (56.3% for the third year and 77.6% for the sixth year), although a good percentage (31%) of the third-year group referred that it should be elective (p ≤ 0.005) **(table 5)**.

DISCUSSION

This study explored the impact of an extracurricular course of radiological anatomy in third (junior) and sixth (senior) year med students. We investigated in which group (junior or senior) of students the use of imaging for learning anatomy had greater effectiveness by comparing their performance in the pre and post-test and evaluating their opinions about the usefulness of the variables (imaging methods, didactic resources, and atlas's features). The main results were that the performance of both groups was very similar, and senior and junior students both improved their output from the pre to post-test. Opinions about the usefulness were positive in both groups. Senior students gave a higher score of benefit in all variables than junior students.

Senior students, in general, scored higher than the junior students on the usefulness of the different radiological techniques, teaching resources, and characteristics of the interactive digital atlas. The authors believe that this difference in more positive opinions in final year students is because they have more insight into the complex dimensions of patient care[20]. In addition, their learning experience during their clinical practices gives them a more positive and practical perception than junior students

of achieving new knowledge and skills that may be useful both for their learning and the comprehensive care of their future patients. It confirms that results and activities help students develop practical skills and a positive mind during medical training[21].

Regarding imaging techniques used in anatomy teaching, our findings coincide with the literature's findings, reflecting CT and X-ray scored higher than MRI and ultrasound[8,22-24]. Computer tomography (CT) images provide a three-dimensional view of the body and help understand topographical relations and improve comprehension of complex anatomical regions[14,17]. In addition, students develop observation skills acquired when they observe the CT scan trying to identify anatomical details. This observation skill is considered the key to long-term retention[25]. Ultrasound obtained the lowest score among the radiological techniques. We believe that it is because the identification of anatomical structures and their interpretation is more complicated. After all, ultrasound's view does not coincide with the mental image that one develops anatomical planes when studying anatomy. Therefore, we believe that its use in the teaching of anatomy is not the most optimal.

Students rated the study guide as the most useful didactic resource, confirming its value as an aid to learning, which coincides with what is reported in the literature[26-30]. Laidlaw & Harden (1990) define the study guide as "an aid, usually in the form of printed notes, designed to assist students with their learning. It indicates what should be learned, how it can be learned, and how students can recognize if they have learned it"[31]. The AMEE guide number 16 (1999) categorized the benefits of a study guide in 3 groups: one, the management of student's learning, two, the provision of a focus for students' activities related to education, and three providing information on the subject or topic[32].

Junior and senior students rated the study guides and the interactive digital atlas as the most helpful didactic resources, suggesting their preference for active and self-directed learning over traditional teaching methods[33]. Since the participants could access the interactive study guides and atlases online, they had the opportunity to work at their own pace in their home, repeat the exercises, and emphasize

the aspects that they considered essential or more difficult. It reinforces the benefit reported by the literature about computer-aided learning, which is the availability of instructional material anytime and anywhere[34,35]. The accessibility of study material and instructions to learn anatomy through images are vital points that encourage self-directed learning and motivate students[25]. The importance of self-directed learning in higher education is that it provides the student with the competence to be responsible for the quality of their knowledge, applying self-determination to learn what they see as imperative for them. It constitutes learning that links life with education[36]. These indicate the importance of emphasizing the students' learning process (how they learn) instead of a list of content to fulfill (what they know). Our finding reinforces the importance of self-directed learning (student as the architect of their education and knowledge) and the teacher's facilitating role.

The digital atlas with the highest score features were the change of view (window), structure search button, and directional arrows and scroll. These tools help explore and recognize the anatomical region to obtain an overview, reinforcing the applying radiological images in anatomy teaching helps to understand complex anatomical parts[6,17].

Years of experience in medical training seem to influence neither performance nor perception concerning the implementation of the radiological anatomy course since junior and senior groups obtained similar scores. Post-test scores improved compared to pre-test for juniors and seniors, reflecting the effectiveness of learning.

The finding that students think the radiology anatomy course should be compulsory reflects that they know this knowledge's lack of medical training and the need to integrate radiology and anatomy at any level (preclinical or clinical years) of the undergraduate medical program. We think that perhaps the most influencing factor was interest and the didactic approach used. The interpretation of imaging is not based on row memory, and it requires logical thinking and reasoning. Therefore, incorporating the integration of anatomy and radiology into the medical curriculum would increase the confidence of students to develop clinical skills and promote

their motivation[25] and should have implications for the planning of vertical integration and curriculum design.

Limitation of the study
Students who participated were volunteers, and therefore interested in learning radiological anatomy. This interest may positively influence their opinions and performance. It would be interesting to implement this course in students who are not interested in radiologic anatomy and explore whether their performance and opinions are positive or negative.

In addition, as the post-test was applied at the end of the course and only for research purposes, we cannot assure if the approach and resources used in this study promote knowledge retention. Further studies should evaluate the long-term impact of this approach and these resources.

CONCLUSIONS
The integration of radiology in the teaching of anatomy positively impacts the perception and performance of medical students in both the preclinical and clinical years. We recommend this integration be implemented through a self-directed learning approach, using CAL (computer-aided learning), and considered complementary teaching method in the medical curriculum as a good alternative for anatomy education in countries where dissection is not feasible.

AUTHORSHIP
- AY-CC, LM, ECh, NS, DR contributed to designing the study, collecting data, analyzing data, writing, and reviewing the manuscript.

PREVIOUS PRESENTATION
None.

CONFLICT OF INTEREST STATEMENT
The authors declare that they have no conflict of interest. 🔍

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