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Anatomic variation of the palmaris long us muscle: A study using the Anatomage Table

Abebe Muche[1,] and Abebe Bekele[2]*

[1]Department of Human Anatomy, University of Global Health Equity, Kigali, Rwanda, [2]Department of Surgery, University of Global Health Equity, Kigali, Rwanda

***Corresponding author:** email:* abemuche14@gmail.com

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Abstract

Background: *The palmaris longus muscle, located in the superficial anterior compartment of the forearm, plays a crucial role in wrist flexion.*

Objective: *This study aimed to investigate the anatomical variation (presence or absence) of the palmaris longus using the Anatomage Table 10.0, a cutting-edge virtual dissection tool.*

Method: *The research was conducted at the University of Global Health Equity's simulation laboratory in Rwanda from June 10 to June 15, 2024. Five cadavers (2 female, 3 male) with varying resolutions were used to examine the muscle's anatomy. Prior to data collection, instructors received training, and a pilot study ensured the reliability and validity of the research. Virtual dissection and labeling of the palmaris longus muscle and corresponding nerves were performed, while preserving key anatomical structures.*

Result: *The study revealed a bilateral absence of the palmaris longus muscle in one cadaver.*

Conclusion: *Our findings on palmaris longus muscle variability highlight the significance of anatomical variations in treatment outcomes and patient care, contributing to the growing understanding of their clinical implications. This variability is crucial for surgeons and clinicians to consider when performing forearm surgeries and diagnosing conditions like carpal tunnel syndrome.*

Introduction

The palmaris longus muscle, slender and fusiform in shape, lies within the forearm's superficial anterior compartment. It originates from the common flexor origin near the medial epicondyle, inserts into the palmar aponeurosis, and is innervated by the median nerve. It is positioned between the flexor carpi radialis and flexor carpi ulnaris muscles and partially overlaps the course of the median nerve (1-3).

Like the plantaris muscle, the palmaris longus exhibits considerable morphological variability (4). These variations of the palmaris longus muscle can include complete agenesis, differences in the location and form of the fleshy portion, abnormalities in attachment, duplication or triplication, accessory tendinous slips, and substitutions by elements with similar form or position (5-7).

The variability of the palmaris longus is significant clinically as it can lead to conditions such as compartment syndrome of the forearm and wrist, carpal tunnel syndrome, or Guyon's syndrome. Its anatomic variability can also contribute to diagnostic challenges for radiologists (8, 9). Furthermore, the palmaris longus serves as a key anatomical landmark for surgeries on the forearm and wrist. Its tendon is widely used in reconstructive plastic surgery for tendon grafting and procedures like lip augmentation (10). The palmaris longus also plays a role in ptosis correction (8, 9) and the management of facial paralysis (11).

The Anatomage method revolutionizes human anatomy visualization through its virtual dissection table, providing users with an unprecedented level of accuracy and creating a paradigm shift in anatomy learning. This fully interactive, life-sized touch screen experience mirrors the conditions of working with a fresh cadaver, using genuine patient data at life-like proportions. The Anatomage Table features a life-sized virtual human cadaver displayed on a 2.13×0.67 m screen, offering the ability to digitally dissect the body. By utilizing advanced imaging technologies such as CT scans, X-rays, ultrasound, and MRIs, all integrated into a user-friendly touchscreen interface, the table transforms the study of human anatomy. Users can explore and peel back layers of the digital body, removing structures from the surface to deeper layers. This allows for the removal of skin to expose muscles, bones, internal organs, nerves, and blood vessels. The table enables students and users to study anatomical structures from multiple perspectives, layers, and scales, promoting a deeper understanding of how the body's parts and organs are interconnected. Anatomage also provides access to anatomical data from both male and female cadavers, sourced from the Visible Human Project (VHP) and the Visible Korean Human (VKH). Additionally, as it is highlighted in studies such as García et al. (2018) ("Possibilities for the use of Anatomage (the anatomical real body-size table) for teaching and learning anatomy with the students") (11).

To our knowledge, this is the first study to analyze palmaris longus muscle variability using the Anatomage Table. The aim of this case study is to enhance understanding of the anatomical differences and variability of the palmaris longus muscle to improve surgical procedures and clinical practices. Based on the Anatomage table study, we found that variations in the presence or absence of the palmaris longus muscle exist among individuals. These variations can significantly impact the planning and execution of surgical procedures involving the forearm and hand, such as carpal tunnel release. The findings underscore the importance of understanding the anatomical differences and variations in the palmaris longus muscle to help surgeons navigate and avoid complications during surgeries in the palmar region.

Material and Method

Study Area and Period

This study was conducted within the simulation laboratory at the University of Global Health Equity in Rwanda. The research took place from June 10 to June 15, 2024, utilizing the Anatomage virtual dissection table 10.0.

Study Design

An observational study design was conducted using an Anatomage virtual dissection Table.

Sample Population

The sample population included all cadavers integrated with the Anatomage Table, consisting of five cadavers (two female and three male). The three cadavers, Hans, Carl and Carla, have a resolution of 0.66mm, 0.66 mm and 1.00 mm while the remaining two, Victor and Vicky have a resolution of 0.80mm in all dimensions (0.80mm, 0.80mm, 0.80mm).

Data Collection

Training and Pilot Study

Before data collection, simulation laboratory instructors underwent two days of training to learn how to use the Anatomage Table and identify anatomical structures such as nerves and muscles. To ensure the reliability and validity of the research instruments, a pilot study was conducted at the University of Global Health Equity. This pilot study focused on the pyramidalis muscle of the abdominal wall, one of the variable muscles, using the Anatomage Table. It involved two cadavers, representing about 30% of the total sample size, and helped identify areas requiring modification.

Data Collection Procedures

The present study utilized Anatomage Table 10.0 to examine variations in the anatomy of the palmaris longus muscle. The latest version, Anatomage Table 10.0, presents meticulously segmented representations of real human anatomy from five cadavers, including a new male cadaver named Hans, reconstructed from a 70-year-old lung cancer patient. Hans provides unique insights into geriatric anatomy, showcasing detailed muscular and vascular systems (see Fig. 1).

Data collection involved peel of the skin, fascia, and muscles of the thoracic wall and upper limb. Additionally, the skull and lower limb were entirely removed from the cadavers. These virtual dissection procedures were performed using the Anatomage Table's dissection tools. The brachial plexus and its terminal branches, including the ulnar and median nerves, and the bony structures of the upper limb, thoracic wall, and vertebral columns, were preserved intact. Moreover, the palmaris longus muscle, along with its origin and insertion, was left untouched.

Following the isolation of the palmaris longus muscle and corresponding nerves, these structures were labeled using the Pen Tool of the Anatomage Table. The pictures were then saved on the Anatomage Table and exported to a personal computer for further assessment.

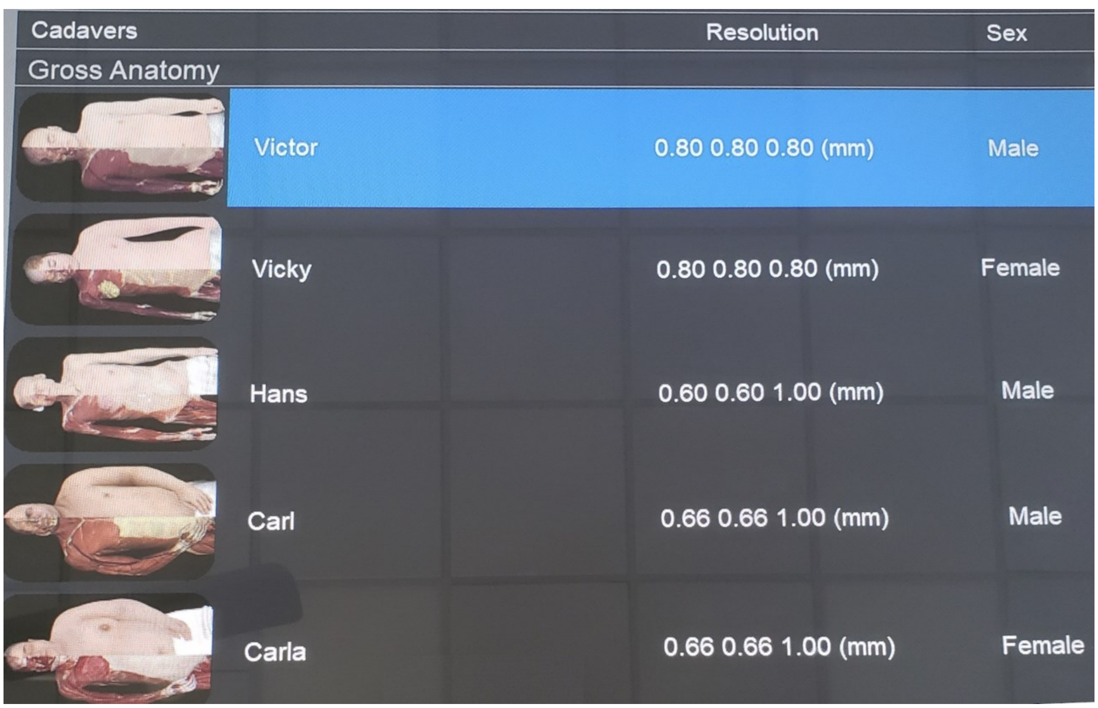

Figure 1: *List of cadavers of Anatomage Table with their corresponding resolution and sex (The names are fictional and were randomly assigned by the Anatomage Table company)*

Result

Since 2020, the University of Global Health Equity in Rwanda has utilized the Anatomage Table, including its latest version, Anatomage Table 10, across various educational disciplines such as gross anatomy, histology, physiology, pathology and radiology. During musculoskeletal studies, muscle origins and insertions were extensively explored using the Anatomage Table 10. In a notable discovery during virtual dissection, a bilateral absence of the palmaris longus muscle was observed in one male cadaver named

Carl (Fig. 6). However, in the remaining four cadavers on the Anatomage table, the palmaris longus muscle was clearly distinct in both right and left forearms. Located medial to the median nerve and lateral to the ulnar nerve, the relationship between the palmaris longus and these nerves in the cadavers Victor, Vicky, Hans, and Carla is detailed in Fig. 2, 3, 4, and 5, respectively.

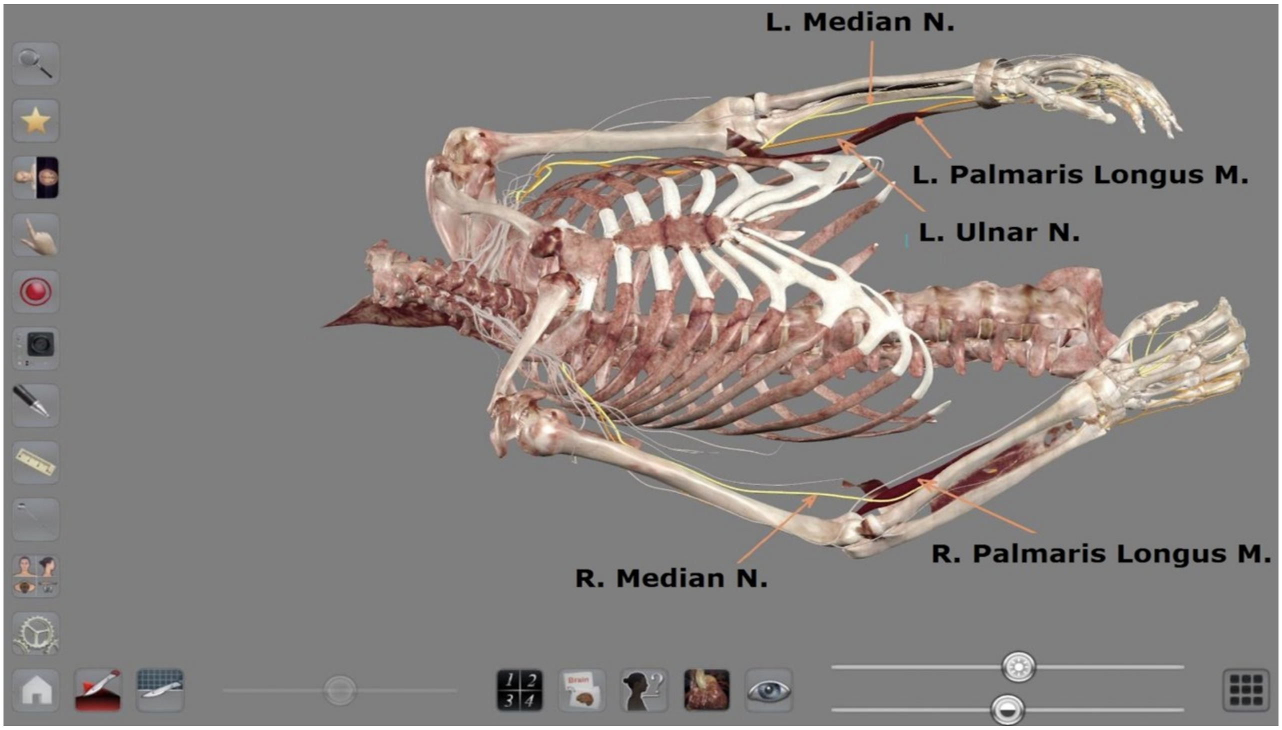

Figure 2: *Representation of the relationship between the palmaris longus and the median nerve of a cadaver named Carla. The palmaris longus tendon essentially crosses over the median nerve.*

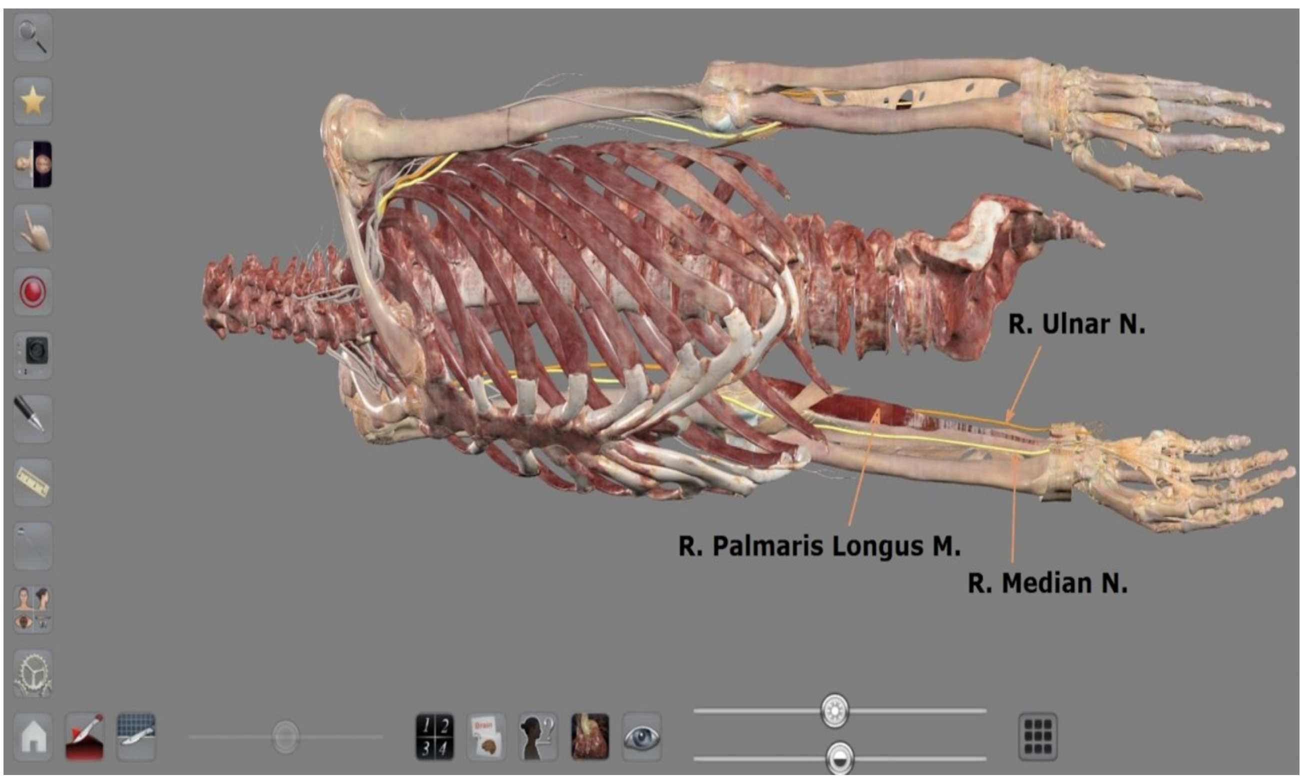

Figure 3: *Representation of the relationship between the palmaris longus and the median nerve of a cadaver named Hans. The palmaris longus tendon essentially crosses over the median nerve.*

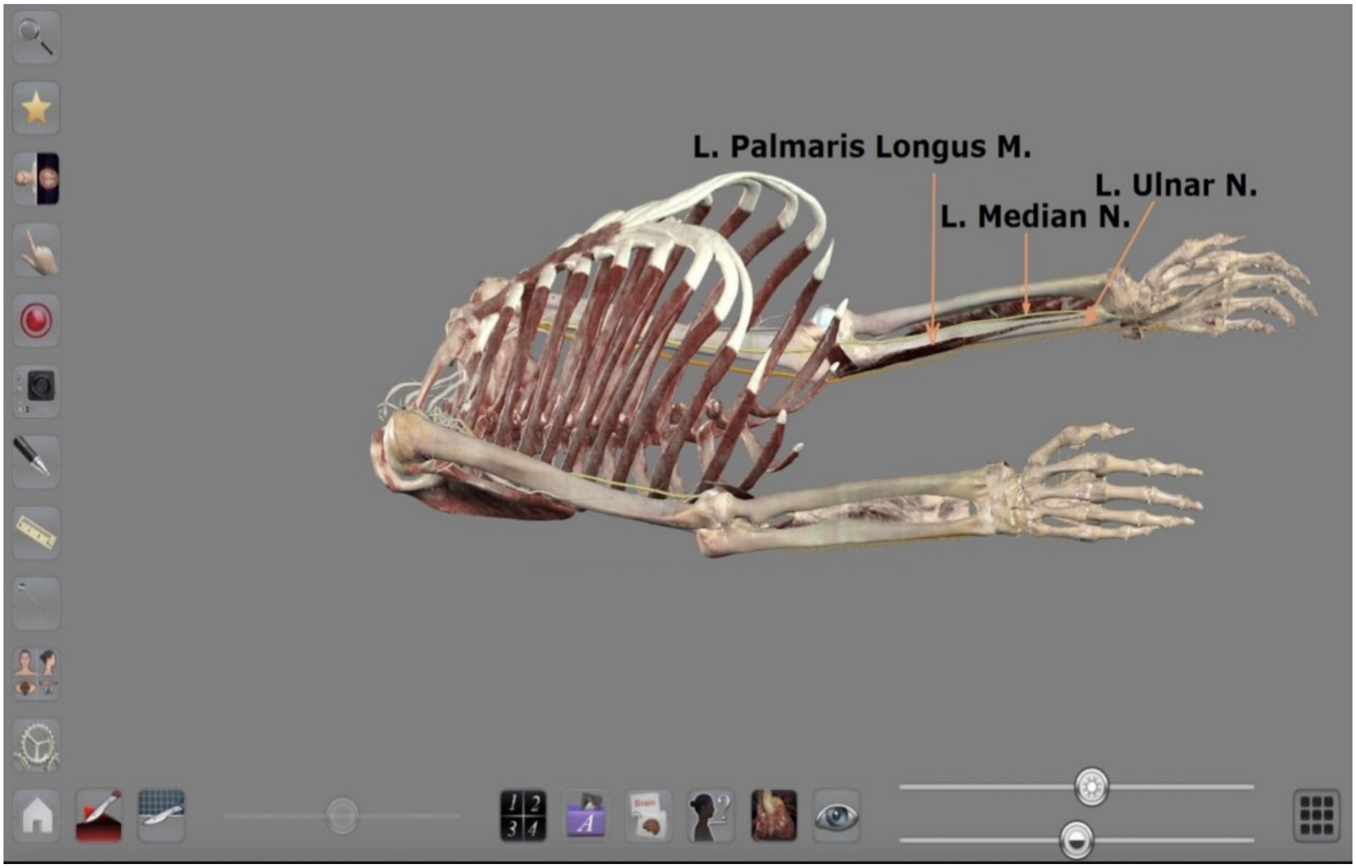

Figure 4: *Representation of the relationship between the palmaris longus and the median nerve of a cadaver named Vicky. The palmaris longus tendon essentially crosses over the median nerve.*

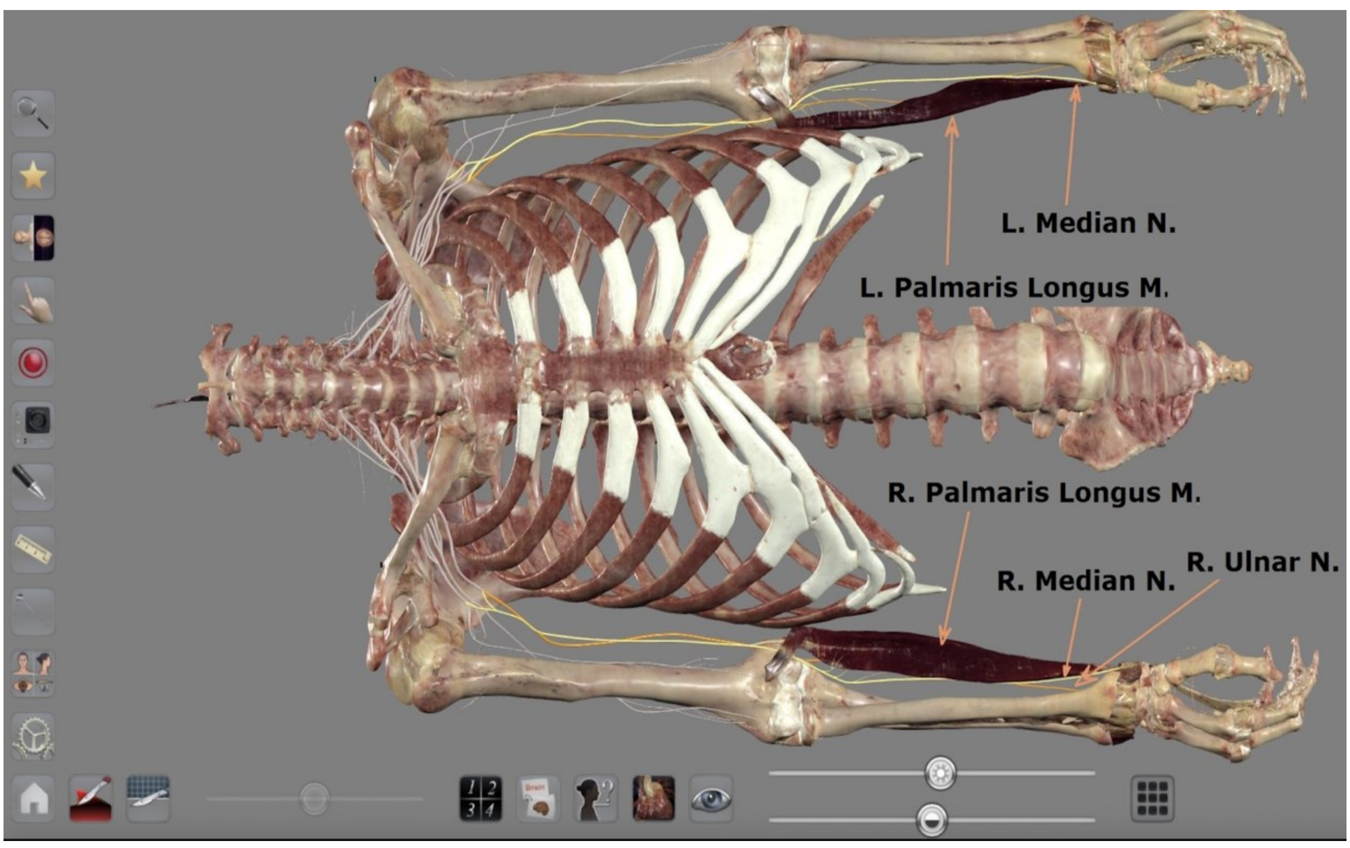

Figure 5: *Representation of the relationship between the palmaris longus and the median nerve of a cadaver named Victor. The palmaris longus tendon essentially crosses over the median nerve.*

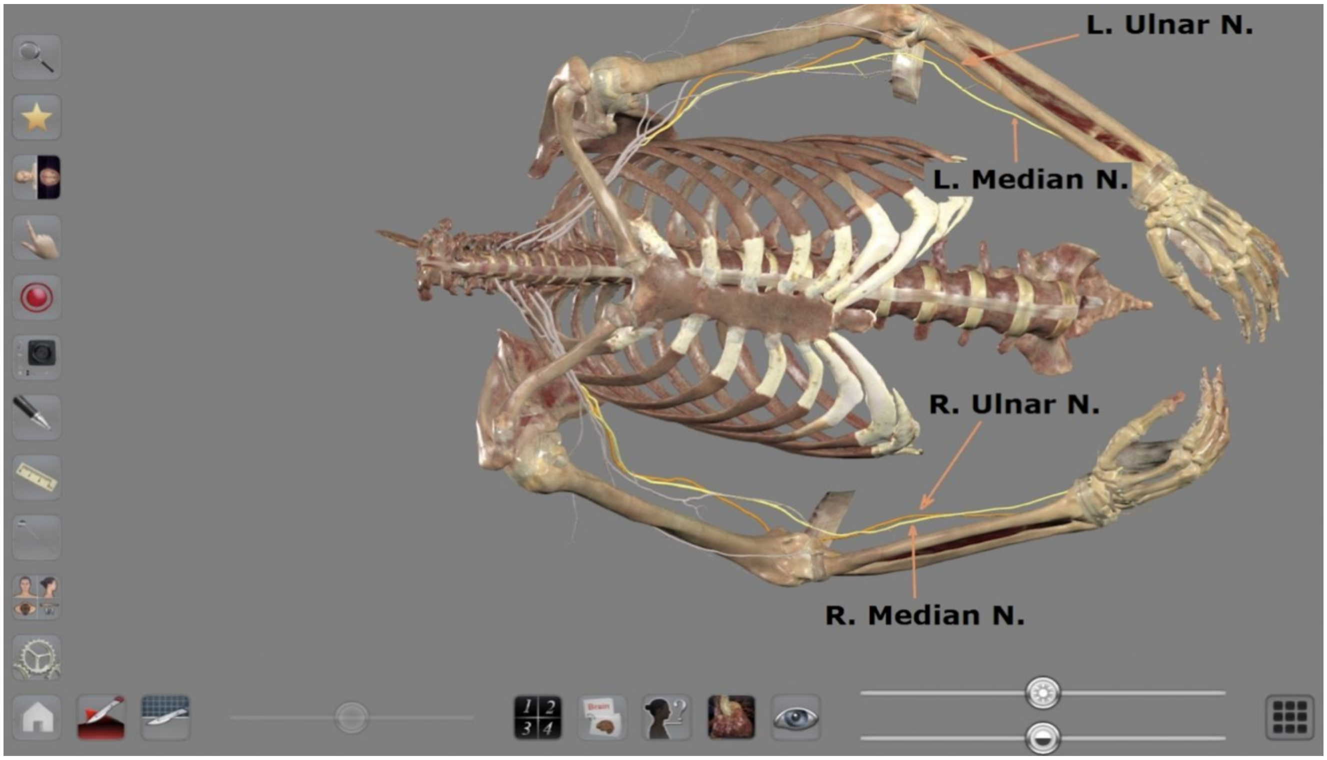

Figure 6: *Representation of the bilateral absence of the palmaris longus muscle, highlighting the location of median and ulnar nerve of a cadaver named Carl.*

Discussion

A recurring theme in anatomy education is the presence of anatomical variations. During demonstrations, scholars often inquire if these variations are reflected among the cadavers included in the Anatomage table. Our study sheds light on this question by quantifying the proportion of such variations within the palmaris longus muscle. We discovered that 20% of the cadavers (1 of the 5) exhibited a bilateral absence of the palmaris longus muscle.

The palmaris longus, plantaris, pyramidalis, peroneus tertius, and psoas minor muscles are well-recognized for their variability among humans. The palmaris longus, characterized by its short belly and long tendon, has been described as a phylogenetically degenerate metacarpophalangeal joint flexor (14, 15). Found only in mammals, this muscle thrives in species that rely heavily on their forelimbs for movement (16). More specifically, the palmaris longus muscle is well developed in species with a high ratio of upper limb weight to body weight. As this ratio is quite low in humans, the palmaris longus is less developed and its role in the functioning of the hand is reduced. As a result, it may exhibit morphological variation (17). In humans, the absence of the palmaris longus is possibly dictated by heredity through a mechanism yet to be fully understood (18).

Standard textbooks of surgery estimate a 15% absence rate for the palmaris longus muscle; however, this figure varies considerably across different ethnic groups (19, 20). In the current Anatomage-based study, we found that the palmaris longus muscle was bilaterally absent in one out of five cadavers examined, representing 20% of the cases. A cross-sectional study of 300 Caucasian subjects (150 males and 150 females) aged 18 to 40 years revealed unilateral and bilateral absence rates of 16% and 9%, respectively (21). In contrast, a study of 329 Chinese subjects in Singapore found a unilateral absence rate of 3.3% and a bilateral absence rate of 1.2%, with an overall absence of 4.6% (22).

Moreover, a study conducted in Nigeria reported that about 31.3% of participants lacked the palmaris longus muscle on either side, with 12.5% exhibiting unilateral absence and about 18.8% showing bilateral absence (23). A comparative study in Northern Iran reported an overall prevalence of right-sided, left-sided, bilateral, and total absence of the palmaris longus muscle at 4.1%, 5.2%, 3.9%, and 13.2%, respectively (24).

Our study is limited by the small sample size of cadavers available on the Anatomage Table. While the observed absence is consistent with findings from many other studies, it cannot be deemed statistically significant given the availability of small number of cadavers.

Conclusion

The findings of our Anatomage table study revealed a bilateral absence of the palmaris longus muscle in Caucasian cadaveric specimen. This morphological variability is clinically significant for diagnosing and treating conditions like carpal tunnel syndrome and is relevant for surgical procedures.

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Additional Information

Disclosures

Human subjects: All authors have confirmed that this study did not involve human participants or tissue.

Conflicts of interest:

In compliance with the ICMJE uniform disclosure form, all authors declare the following:

Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work.

Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.

Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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