

Coexistence of rare variations of palmaris profundus and flexor superficialis muscle

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The superficial layer of the anterior compartment of the forearm is characterized by different morphological variations. During standard anatomical dissection, two morphological variations in the superficial compartment of the forearm were observed. The first one was the palmaris profundus, which originated from the radius and distally fused with the tendon to 3rd digit (from the flexor digitorum superficialis muscle) inserted on the medial phalanx of the third digit. The second variation was a distinct superficial flexor of the 4th digit represented by one muscle belly with originated from a common mass from the medial humeral epicondyle, passes through the carpal tunnel, and is inserted into the medial phalanx of the fourth digit. The flexor digitorum superficialis muscle was located deeply to it and it was divided only into three tendons (to 2nd, 3rd and 5th digits). Tendons connected to the 2nd and 3rd digits were crossed with each other at the level of carpal tunnel. From the humeroulnar head of the flexor digitorum superficialis muscle, an additional muscle belly was arising and its tendon was fused with the superficial flexor of the fourth digit. Knowledge about morphological variations in this region is clinically important because of the direct correlation with the median nerve, and the possibility to cause carpal tunnel syndrome. (Folia Morphol 2024; 83, 2: 482–488)

Keywords: palmaris profundus, flexor digitorum superficialis, accessory structure, median nerve entrapment, carpal tunnel, accessory tendon to the fourth finger, neuropathy, ulnar artery

INTRODUCTION

The superficial layer of the anterior compartment of the forearm is characterized by different morphological variations. This compartment is composed of: the palmaris longus muscle (PLM), the flexor carpi radialis muscle, the flexor carpi ulnaris muscle, the pronator teres muscle and the flexor digitorum superficialis muscle (FDSM) [9].

The FDSM is represented by two heads: humeroulnar (originated from the medial humeral epicondyle and olecranon) and the radial one (originated from

the oblique line of radius). This muscle is distally divided into four tendons inserted into the middle phalanx of four fingers (II–V). It is innervated by the median nerve (MN) [9].

The PML is proximally attached to the medial epicondyle of the humerus. Its insertion is represented by the flattening of the flexor retinaculum and the lower part of the palmar aponeurosis. This muscle is also innervated by MN. Some interesting variations of this muscle may occur, like its absence, duplication, accessory head or tendon, reversed PLM (with or

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without accessory abductor digiti minimi), bifid PLM, and others [1].

Knowledge about the above morphological variations is very necessary, especially in diagnosis and looking for the reason for MN entrapment. Both muscles are located in the immediate vicinity of this nerve, so most of their variations may result in such pathology.

During standard anatomical dissection, two morphological variations in the superficial compartment of the forearm were observed. The first one was the palmaris profundus originated from the radius and distally fused with the tendon to 3rd digit (from FDSM) inserted on the medial phalanx of the third digit. The second variation was associated with the FDSM. Not only its muscular part was variable, but its tendinous part was too. A distinct flexor superficialis muscle was observed and represented by one muscle belly originating from a common mass from the medial humeral epicondyle, passing through the carpal tunnel, and inserted into the medial phalanx of the fourth digit. It was located superficially to the standard FDSM. In turn, standard FDSM was characterized by two heads (humeroulnar and radial) divided into three tendons (to the 2nd, 3rd, and 5th digits). Tendons to the 2nd and 3rd digits were crossed with each other at the level of carpal tunnel. From the humeroulnar head of the FDSM additional muscle belly was arising and its tendon was fused with the muscle belly of the flexor superficialis to the fourth digit. Most morphological variations in this region are clinically important because of the direct correlation with MN.

CASE REPORT

A female cadaver, 87 years old at death, donated to science, was subjected to routine anatomical dissection for research and teaching purposes at the Department of Anatomical Dissection and Donation, Medical University of Lodz, Poland. The right upper limb was subjected to traditional anatomical dissection [10], and morphological variations in the forearm region were found.

The first anatomical variation was the palmaris profundus. It originated from the radius and at this point, it was 13.16 mm wide, and 1.90 mm thick. Its distal part was fused with tendon to 3rd digit (from FDSM) and at the point of their fusion, it was 3.66 mm wide and 1.00 mm thick. Its common insertion was located on the medial phalanx of the 3rd digit. Its proximal part was located just above the MN, and its distal part was just below the MN.

The second variation was associated with the FDSM. The superficial flexor to the 4th digit was a distinct structure and was located superficially to standard FDSM. This anomalous muscle was represented by one muscle belly originating from a common mass from the medial humeral epicondyle. Its length was 185.16 mm. The musculotendinous junction (the connection between its muscular and tendinous parts) was 4.51 mm wide and 1.57 mm thick. The tendon of the superficial flexor to the 4th digit was 150.76 mm long and its insertion (5.24 mm wide, and 1.80 mm thick) was located on the medial phalanx of the 4th digit.

Under this muscle, there was a standard FDSM; however, its distal part was divided only into three tendons to the 2nd, 3rd, and 5th digits (without tendon to 4th digit). This muscle was represented by two heads, the radial one, and the humeroulnar one. The interesting thing was a special muscular connection between them. The muscular belly of the radial part was 159.14 mm long, and it was passing by a musculotendinous junction (5.33 mm wide, 1.78 mm thick) into a tendon whose length was 135.41 mm and insertion was located on the medial phalanx of the 3rd digit. The muscle belly of the humeroulnar part gave two tendons (to the 2nd and 5th digits). The length of the muscular part associated with the 2nd digit was 217.55 mm, and the musculotendinous junction was 6.87 mm wide and 1.04 mm thick. Its tendon was 107.85 mm long and attached to the medial phalanx of the 2nd digit. In turn, the length of the muscular part associated with the 5th digit was 190.64 mm long, and in the musculotendinous junction was 2.47 mm wide and 1.95 mm thick. Its tendon was 98.58 mm long and inserted on the medial phalanx of the 5th digit. Tendons to the 2nd and 3rd digits crossed each other in the carpal tunnel.

From the common humeroulnar head of the FDSM another accessory muscular structure was arising. Its origin was 2.48 mm wide, and 1.31 mm thick. The length of the muscle belly was 48.72 mm. Its musculotendinous junction was 1.34 mm wide, and 0.34 mm thick. Its distal part was represented by a tendon whose length was 52.12 mm, and this tendon was fused with the mentioned variation — the superficial flexor of the 4th digit. At the point of their fusion, it was 1.04 mm wide and 0.32 mm thick.

Both, the FDSM's tendons (to the 2nd, 3rd, and 5th digits) and the superficial flexor of the 4th digit were passing through the carpal tunnel just below the MN (Fig. 1–5).

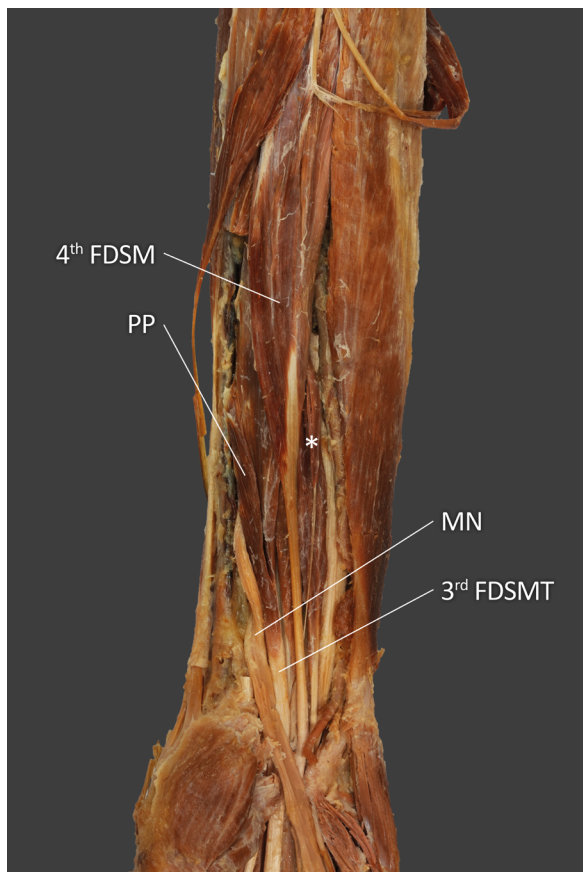


Figure 1. PP — palmaris profundus muscle, 4th FDSM — flexor digitorum superficialis muscle to 4th digit, 3rd FDSMT — tendon of flexor digitorum superficialis muscle to 3rd digit, MN — median nerve, *additional muscle belly.

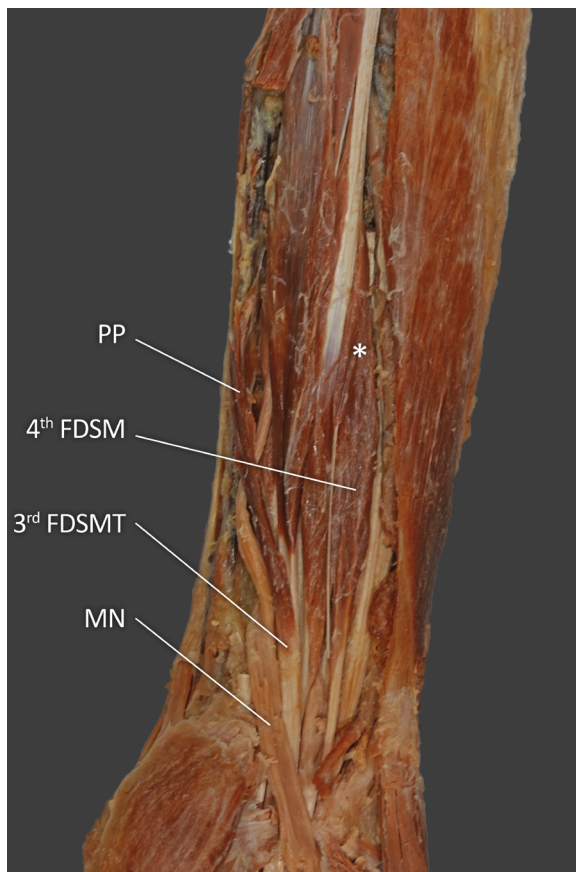


Figure 2. PP — palmaris profundus muscle, 4th FDSM — flexor digitorum superficialis muscle to 4th digit, 3rd FDSMT — tendon of flexor digitorum superficialis muscle to 3rd digit, MN — median nerve, *additional muscle belly.

During the dissection of the upper limb, no other morphological variabilities were found. Table 1 shows the morphometric measurements of the present case.

DISCUSSION

Morphological variations in the anterior compartment of the forearm are very important. The first example proves this statement is factual, as it may cause the MN's compression and leads to neuropathy.

One of morphological variation of the PLM is the palmaris profundus, first described by Froshé and Frankel [7]. Reimann et al. [13] carried out a study and assessed the prevalence of this muscle, which was only 0.19% [13].

Takanashi et al. [14] found this structure coursed laterally to the FDSM. Its proximal attachment was located on the anterior surface of the radius, whereas its distal part was represented by a tendon attached to the flexor retinaculum. The palmaris profundus coursed radially to the MN [14].

Pirola et al. [11] carried out a study and distinguished three types based on proximal attachment of the palmaris profundus. The first type was represented by muscle originating from the mid-third radius. This type was also called flexor carpi radialis profundus muscle. The second type was characterized by an origin arising from the flexor digitorum superficialis fascia and it was also called palmaris profundus longus muscle. The third type was proximally attached to the ulna and was named the palmaris profundus ulnaris muscle [11]. Of course, the palmaris profundus may originate from other structures like a common mass of medial humeral epicondyle, PLM, and flexor pollicis longus.

Van Denmark et al. [4] described a case of a patient with palmaris profundus. The patient complained of night paraesthesias and exacerbation of symptoms after writing. This patient was treated surgically by standard open carpal tunnel release. The anomalous structure — palmaris profundus was observed in the

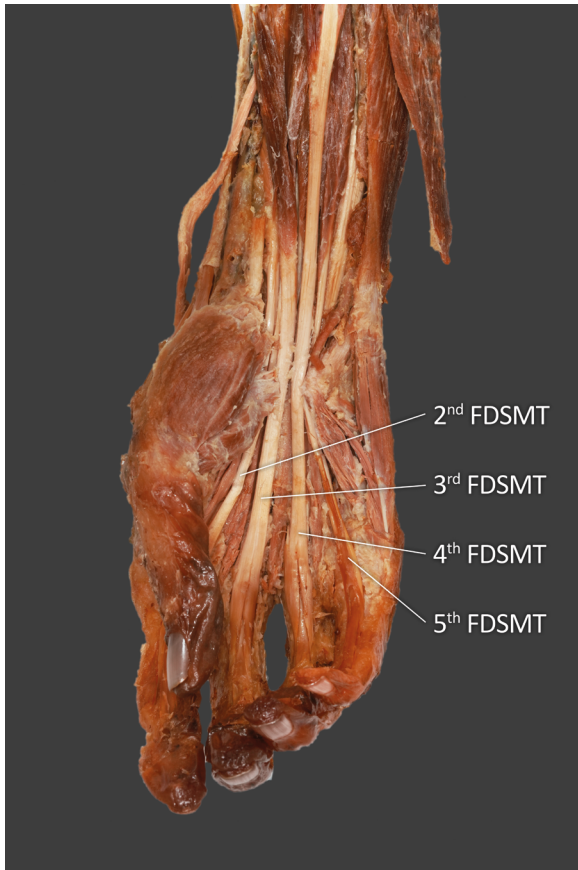


Figure 3. 2nd FDSMT — tendon of flexor digitorum superficialis muscle to 2nd digit, 3rd FDSMT — tendon of flexor digitorum superficialis muscle to 3rd digit, 4th FDSMT — tendon of flexor digitorum superficialis muscle to 4th digit, 5th FDSMT — tendon of flexor digitorum superficialis muscle to 5th digit.

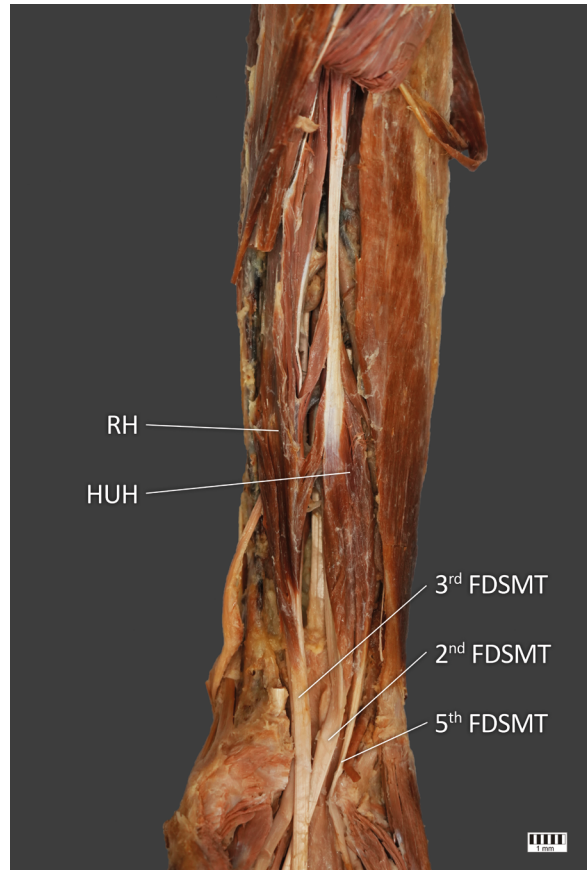


Figure 4. RH — radial head of flexor digitorum superficialis muscle, HUH — humeroulnar head of flexor digitorum superficialis muscle, 2nd FDSMT — tendon of flexor digitorum superficialis muscle to 2nd digit, 3rd FDSMT — tendon of flexor digitorum superficialis muscle to 3rd digit, 5th FDSMT — tendon of flexor digitorum superficialis muscle to 5th digit.

carpal tunnel, just above the MN. Complete resolution after open carpal tunnel release occurred [4].

Flores et al. [6] also described a patient with carpal tunnel syndrome related to palmaris profundus. This patient was treated surgically with a central open approach. It turned out, that in this region the palmaris profundus originated from the proximal part of the carpal tunnel and inserted into the palmar fascia was observed. During surgery, this anomalous structure was partially resected [6].

In the present case, the occurrence of the palmaris profundus may be also associated with MN compression. It originated from the anterior part of the radius and inserted into the tendon from the standard FDSM. Although the MN coursed distally above this muscle (at the level of fusion between the palmaris profundus and tendon to the 3rd digit from FDSM), this nerve was also located under the middle part of

the palmaris profundus. In this place, there is a high risk of compression of the MN.

Morphological variations of the FDSM may be also associated with MN neuropathy, and knowledge about them seems to be also helpful.

One of variation is an absence of its part, for example, lack of the tendon to the 5th digit, which is the most common. Of course, in the available literature, the absence of tendon to the 2nd, 3rd, and 4th digits was also noticed. Sometimes, the whole muscular part (radial or humeroulnar) is absent [8, 15]. When there is an absence of tendinous part to the 4th digit, an additional muscle may be observed (for example from the medial collateral ligament of the ulna, the transverse carpal ligament, or palmar aponeurosis). On the other hand, there are also cases in which the tendon to the 4th digit arising from the radial head of the FDSM [1]. Another variation is

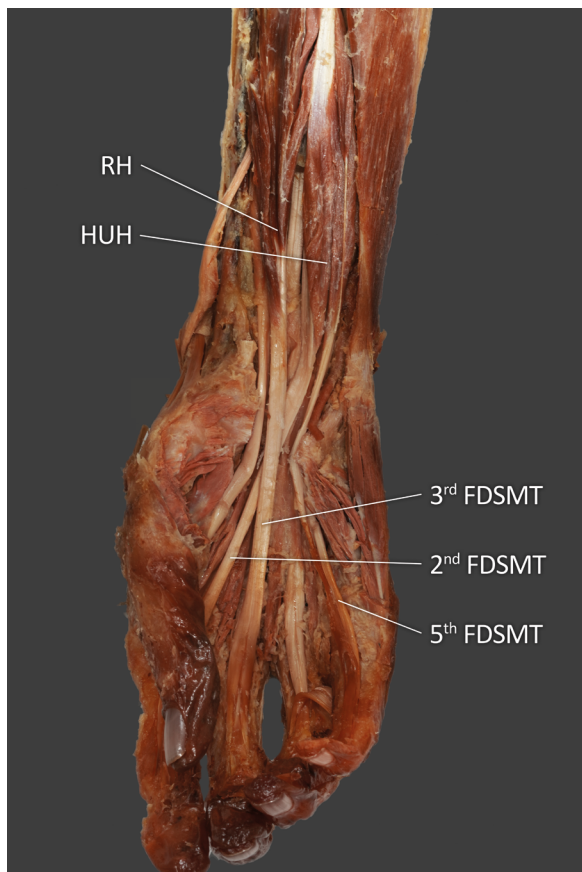


Figure 5. RH — radial head of flexor digitorum superficialis muscle, HUH - humero-ulnar head of flexor digitorum superficialis muscle, 2nd FDSMT — tendon of flexor digitorum superficialis muscle to 2nd digit, 3rd FDSMT — tendon of flexor digitorum superficialis muscle to 3rd digit, 5th FDSMT — tendon of flexor digitorum superficialis muscle to 5th digit.

a connection between FDSM and flexor digitorum profundus [12].

Accessory structures associated with the FDSM are another type of morphological variation. For example, additional slips from the tuberosity of the ulna to the 2nd and 3rd digits may be noticed. Moreover, anomalous slip arising from the FDSM and fused with the brachioradialis tendon may be also observed [1].

Sometimes, the whole muscular part of the FDSM may be digastric; however, this is a very rare variation. Accessory FDSM may be represented by an origin located on the palmar fascia, and insertion located on the fused with the flexor tendon of the index finger (at the level of the metacarpophalangeal joint [1].

Caetano et al. [3] found accessory FDSM originated from the medial humeral epicondyle, next to the superficial heads of the pronator teres muscle. A connection between this accessory structure and FDSM by a thick tendon was also observed. What is interesting is that this anatomical variation was characterized by an intermediate tendon and two muscular parts. The muscular part of this anomalous muscle was localized superficially to the MN and anterior interosseous nerve.

Elliot et al. [5] carried out a study that distinguished five types of FDSM's variations. The first type was represented by the connection between the tendons of the FDSM itself. The second type was characterized by a connection between the tendons of the FDSM and the flexor retinaculum. Type III was

Table 1. Morphometric measurements of the present case

	Palmaris profundus	Flexor superficialis to 4 th digit	FDSM			Accessory structure between FDSM and flexor superficialis to 4 th digit
ORIGIN	Radius	Common mass of medial humeral epicondyle	Common mass of medial humeral epicondyle			Humero-ulnar head of the FDSM
Width	13.16 mm					2.48 mm
Thickness	1.90 mm					1.31 mm
LENGTH			To 3 rd digit	To 2 nd digit	To 5 th digit	
Muscular part	92.35	185.16 mm	159.14 mm	217.55 mm	109.64 mm	48.72 mm
Tendinous part	–	150.76 mm	135.41 mm	107.85 mm	98.58 mm	52.12 mm
MJ						
Width	–	4.51 mm	5.33 mm	6.87 mm	2.47 mm	1.34 mm
Thickness		1.57 mm	1.78 mm	1.04 mm	1.95 mm	0.34 mm
INSERTION	Fusion with tendon to 3 rd digit from the FDSM	Medial phalanx of 4 th digit	Medial phalanx of 3 rd digit	Medial phalanx of 2 nd digit	Medial phalanx of the 5 th	Fusion with the superficial flexor of the 4 th digit
Width	3.66 mm	5.24 mm				1.04 mm
Thickness	1.00 mm	1.80 mm				0.32 mm

FDSM — flexor digitorum superficialis muscle; MJ — myotendinous junction.

a digastric FDSM. Type IV was represented by distal extension of the muscle belly of the FDSM. And the last type was a group of different morphological variations of the FDSM [5].

In the present case, variation of the FDSM depended on distinct superficial flexor of the 4th digit (represented by one muscle belly originating from common mass from the medial humeral epicondyle, passing through the carpal tunnel, and inserted to the medial phalanx of the fourth digit). The FDSM was located deeply to it and it was divided only into three tendons (to 2nd, 3rd, and 5th digits). Tendons to the 2nd and 3rd digits were crossed with each other at the level of carpal tunnel. From the humeroulnar head of the FDSM, an additional muscle belly was arising and its tendon was fused with the superficial flexor of the fourth digit. Based on the classification system created by Elliot et al. [5], this is a Type V of morphological variation.

Interestingly, a similar case of morphological variation in the forearm region was found by Bernardes et al. [2]. The PLM's fibres converged to a tendinous structure passing under the flexor retinaculum. Its insertion was located on the middle phalanx of the 4th digit. There was no tendon from FDSM to this digit. The FDSM was represented by two muscular heads: humeroulnar head which was divided into two tendons — to 2nd and 5th digits, and radial head given only one tendon — to 3rd digit [2].

As it mentioned above, morphological variations in the forearm may be associated with the compression of some neurovascular structures, especially the MN. Structures like palmaris profundus, the reversed PML, or accessory PML may cause the entrapment of the MN, which may result in carpal tunnel syndrome. The main symptoms of such pathology are numbness, tingling, and pain in the innervated region. Moreover, lack of sensation in the region the of thumb, index finger, middle finger, and the thumb side of the 4th finger may also occur.

In the present case, variation associated with the FDSM and occurrence of separated flexor superficialis to the fourth digit is not connected with a higher possibility of MN's compression. All tendons are located in the carpal tunnel just below the MN, so it is impossible. However, because of the presence of the palmaris profundus, the patient may have complained of some symptoms. The proximal part of this accessory structure is muscular and is located just above the MN, so at this point, the MN may be compressed.

In the present case, the ulnar artery may be also entrapped. The main reason is an occurrence of a special course of the flexor retinaculum. There is a special hole and the ulnar artery may pass through it, but proximally to this hole, the ulnar artery is located just below this retinaculum. It may result in decreased blood supply to the hand, sometimes represented by 4th and 5th finger pale, numbness and tingling of the hand and fingers, and also wrist pain.

To treat the above pathologies, knowledge about the morphological variability of the muscles in the forearm region seems helpful.

CONCLUSIONS

Muscles of the forearm region are characterized by different morphological variations. Some of them, for example, palmaris profundus, reversed PLM, or accessory bellies and muscles may compress neurovascular structures such as MN or ulnar artery. It usually results in numbness, tingling, and pain. For that reason, knowledge about morphological variations in this may help in the treatment of these pathologies.

ARTICLE INFORMATION AND DECLARATIONS

Ethics statement

The cadavers belonged to the Department of Anatomical Dissection and Donation, Medical University of Lodz.

Conflict of interest: None declared.

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