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Persistent median artery in carpal tunnel release: prevalence and surgical implications

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ABSTRACT

Aims: This study evaluates intraoperative anatomical variations encountered during open carpal tunnel release (CTR) and aims to determine the prevalence of the persistent median artery (PMA) encountered during open CTR and to evaluate its anatomical features, clinical significance, and surgical outcomes.

Methods: This retrospective observational study reviewed the operative reports of patients who underwent open CTR at our institution between January 2015 and April 2024. Adults diagnosed with carpal tunnel syndrome based on clinical and electrophysiological findings who were treated with isolated open CTR were included. Patients undergoing additional wrist procedures or revision CTR were excluded. The primary endpoint was the intraoperative identification of PMA, defined as an artery persisting within the carpal tunnel. Operative notes were examined to record their anatomical course and management.

Results: A total of 1,032 patients underwent CTR [mean age 53.4±11.6 years; 678 females (65.7%)]. PMA was identified in 9 cases (0.9%), with a mean age of 51.2±8.7 years and predominance in females (66.7%). The PMA coursed superficial to the median nerve in 6 patients (66.7%) and deep to the median nerve in 3 patients (33.3%). All arteries were preserved, and no intraoperative vascular or neural injuries occurred. The mean postoperative follow-up duration was 6.2±2.4 months. No hematoma, wound complications, or symptom recurrence were reported during the follow-up period.

Conclusions: PMA is a rare anatomic variant encountered in less than 1% of open CTR procedures. Its close relationship with the median nerve, although rare, emphasizes the importance of careful dissection. Recognition of this structure intraoperatively may help minimize complications and ensure safe surgical outcomes.

Introduction

Carpal tunnel syndrome (CTS) is the most common entsrapment neuropathy of the upper extremity, resulting from compression of the median nerve as it passes through the carpal tunnel at the wrist (1).This syndrome usually presents with symptoms such as numbness, tingling, and pain in the distribution of the median nerve and, in advanced cases, motor weakness and thenar muscle atrophy (2). Surgical decompression of the carpal tunnel is widely accepted as an effective treatment for patients with moderate to severe symptoms (3). Although carpal tunnel anatomy is generally predictable, surgeons must be alert to anatomic variations that may affect the surgical approach and outcome (4). One of these variations is the persistent median artery (PMA), a developmental vascular structure that does not regress during embryogenesis. While it usually regresses by the eighth week of intrauterine life, the median artery may persist in a small percentage of individuals (5). Its presence may be incidental or may contribute to median nerve compression through direct mass effect or associated thrombosis or aneurysm formation (6).

The prevalence of PMA in the general population is variable, ranging from 1% to 27%, largely due to methodological differences among cadaveric, radiological, and intraoperative studies, as well as population-specific anatomical variation (7,8). The artery may course superficial to or deep to the median nerve and, in some cases, make a significant contribution to the palmar arch, making its preservation important. Inadvertent damage to the PMA during carpal tunnel release (CTR) can result in bleeding, a hematoma, or more serious complications if the PMA is dominant.

In this study, we describe the intraoperative findings of PMA encountered during routine open CTR. We hypothesized that the PMA is a rare but clinically significant anatomic variant that can be encountered during open CTR and that its recognition and preservation contribute to safe surgical outcomes.

Methods

Study design and ethical approval

This retrospective study was conducted after obtaining internal ethical approval from the Selçuk University Rectorate Local Ethics Committee and in accordance with the principles outlined in the Declaration of Helsinki (approval no: 2025/329, date: 03.06.2025). The medical records of patients who underwent CTR surgery at our institution between January 2015 and April 2024 were reviewed.

Patient selection

Preoperative diagnosis of CTS was based on clinical symptoms and supported by NCS. Patients who received CTR under regional anesthesia, local anesthesia, or wide-awake local anesthesia without a tourniquet (WALANT) were included in the study.

Inclusion criteria:

• Adults diagnosed with CTS by clinical and nerve conduction studies (NCS) findings.

• Treated with isolated open CTR.

Exclusion criteria:

• Revision CTR.

• Concomitant wrist procedures (e.g., tendon transfers, mass excisions).

• Incomplete records or inadequate follow-up.

Surgical technique

All procedures were performed by fellowship-trained hand surgeons or orthopedists using a standard open technique via a longitudinal palmar incision. When the PMA coursed deep to the median nerve, careful blunt dissection was performed to expose the artery, and the artery was preserved in all cases without ligation. No attempt was made to mobilize or transpose the artery if it was asymptomatic.

Data collection and intraoperative assessment

Demographic data, including age, sex, laterality, and anesthesia type, were recorded. Operative notes were carefully reviewed to identify cases in which a PMA was noted intraoperatively (Figure 1). The presence, size, location (relative to the median nerve), and management of the PMA (e.g., preserved or ligated) were documented when available.

Intraoperative complications, including vascular injury, excessive bleeding, or nerve damage, were also noted.

Postoperative follow-up

Postoperative follow-up data, including early complications and recurrence, were reviewed when available.

Statistical analysis

Statistical analysis were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). The study cohort included over 1,000 consecutive cases of CTR, ensuring adequate power for descriptive analysis of anatomical variations. Descriptive statistics were used to summarize demographic data and the frequency of PMA. Continuous variables were presented as means and standard deviations, and categorical variables were reported as frequencies and percentages.

Results

A total of 1,032 patients underwent open CTR at our institution between January 2015 and April 2024. Of these, 678 (65.7%) were female, 354 (34.3%) were male, and their mean age was 53.4±11.6 years (range: 27-81). Surgery was

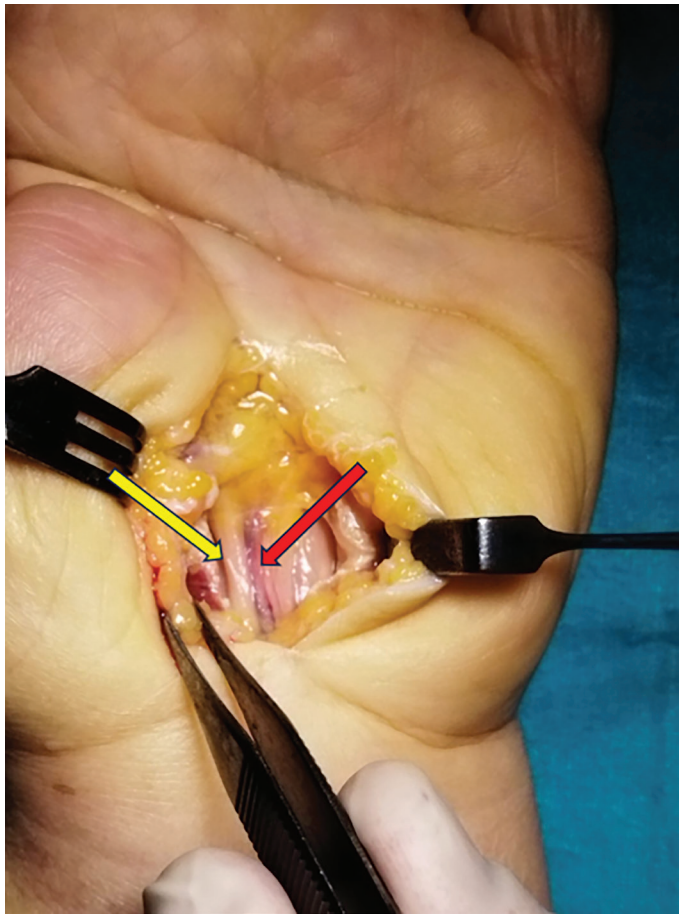

Figure 1. Persistent median artery (red arrow) and median nerve (yellow arrow)

performed on the right wrist in 562 cases (54.4%) and on the left wrist in 470 cases (45.6%).

Procedures were performed under local anesthesia in 612 patients (59.3%), under regional anesthesia in 298 patients (28.9%), and with the WALANT technique in 122 patients (11.8%) (Table 1).

PMA was encountered in 9 patients (0.9%) during surgery. 6 of them were female, and 3 were male, and the mean age was 51.2±8.7 years. PMA was located superficial to the median nerve in 6 patients (66.7%) and deep to the median nerve in 3 patients (33.3%) (Table 2). In 5 cases (55.6%), the artery showed significant pulsatility and appeared to contribute to distal perfusion, necessitating careful dissection and preservation. In all cases, the artery was unilateral; bilateral PMA was not observed.

All PMAs were successfully preserved without ligation (Figure 2). No vascular injuries, intraoperative bleeding, or thrombotic events were reported in PMA-positive cases. Surgeons reported that the presence of the artery necessitates a more meticulous dissection, especially when it courses superficial to the nerve.

Table 1. Patient characteristics and anesthesia types (n=1.032)

Variable	Mean ± SD
Mean age (years)	53.4±11.6
	n (%)
Gender	
Female	678 (65.7)
Male	354 (34.3)
Laterality	
Right	562 (54.4)
Left	470 (45.6)
Local anesthesia	612 (59.3)
Regional anesthesia	298 (28.9)
WALANT	122 (11.8)

SD: Standard deviation, WALANT: Wide-awake local anesthesia no tourniquet.

Postoperative follow-up time was 6.2±2.4 months. During the follow-up period, all 9 PMA-positive patients experienced relief of their preoperative symptoms, and no complications such as hematoma, wound dehiscence, delayed healing, or symptom recurrence were observed.

Discussion

The presence of PMA within the carpal tunnel is a rare but surgically important anatomical variation. Although often overlooked, PMA may influence both the pathophysiology of CTS and the safety of surgical intervention. In our cohort of 1,032 patients undergoing open CTR over nine years, we identified PMA in 9 patients, corresponding to a prevalence of 0.9%. This finding is consistent with previously reported intraoperative prevalence rates ranging from 0.6% to 8.3% (9-11).

The prevalence reported in our study is significantly lower than that reported in many anatomical and radiological studies. This discrepancy can be explained by methodological differences: cadaveric studies generally report rates between 4% and 27% depending on population, dissection technique, and definition criteria (12-15), while imaging studies, such as high-resolution ultrasonography, reveal rates around 6-15% (16). In contrast, clinical surgical series that rely on intraoperative identification, such as Osiak et al. (17), report lower prevalence values (2.8%), which are more consistent with our findings. Our relatively low rate of 0.9% may therefore be attributable to the limitations of intraoperative detection in the absence of preoperative imaging or detailed dissection protocols. Unlike imaging-based studies, we did not employ Doppler ultrasonography or manyetik rezonans imaging, and thus our data reflect only arteries that were macroscopically evident at the time of surgical exploration.

The clinical importance of the PMA during CTR extends beyond its anatomic curiosity. Several case reports have highlighted examples of intraoperative bleeding, nerve

compression, and ischemic complications associated with PMA injury or thrombosis (18-20). In our series, the PMA was most commonly located superficial to, or anteromedial to, the median nerve, and in no case required ligation. No postoperative vascular or neurologic complications were observed, which is consistent with the literature suggesting that, with adequate surgical awareness, the PMA can be safely preserved without adverse outcomes.

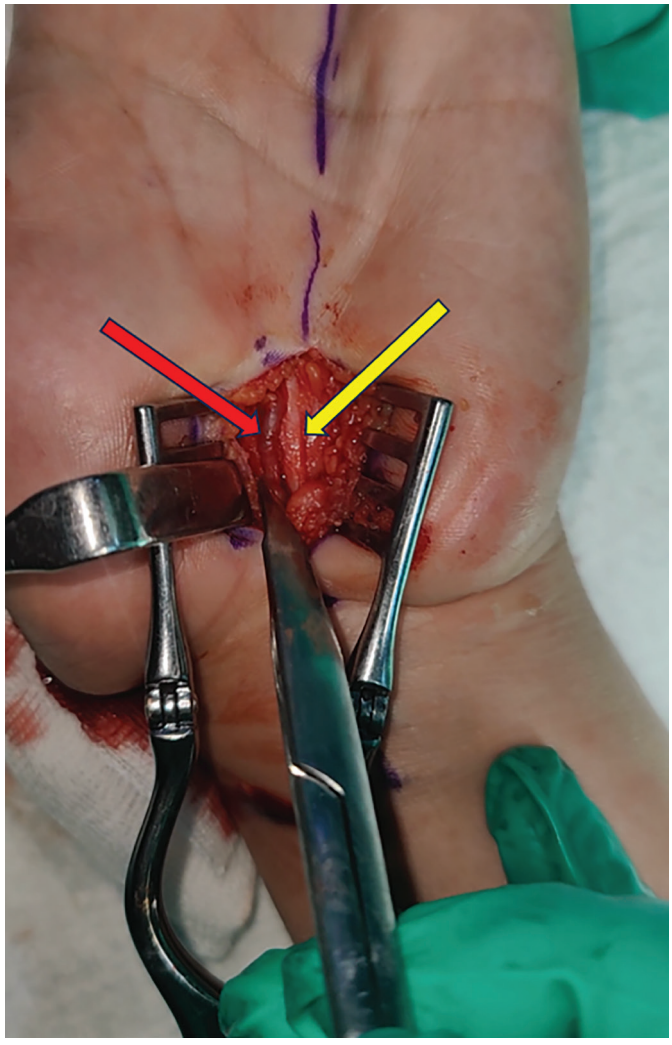

Figure 2. Persistent median artery (red arrow) and median nerve (yellow arrow)

In recent years, preoperative ultrasonography has been emphasized as a useful tool in detecting vascular variants in patients scheduled for CTR, especially in those with atypical symptoms or revision cases (21,22). High-frequency ultrasound can detect PMA and bifid median nerve preoperatively, potentially reducing intraoperative surprises and complications. Although routine imaging is not cost-effective for all patients, its selective use in complex or high-risk cases has been recommended in recent guidelines (23).

Another important aspect is the evolving trend toward ultrasound-guided and endoscopic CTR techniques. While these approaches offer benefits, including reduced morbidity and faster recovery, they also limit direct visualization of the structures within the carpal tunnel. Some authors have expressed concern that unrecognized PMA may increase the risk of iatrogenic vascular injury in such situations (24,25). Therefore, attention to anatomy is essential regardless of the technique chosen. Future research should aim to establish standardized protocols for both preoperative evaluation and intraoperative management of PMA, encompassing both traditional open and novel minimally invasive techniques.

Study Limitations

We acknowledge that our study has several limitations, including its retrospective design and reliance on surgeon-reported intraoperative findings, which may introduce observational bias. The lack of preoperative vascular imaging limits our ability to estimate the “true” anatomic prevalence of PMA in this population. Another limitation is the absence of inter-surgeon reliability assessment. Although procedures were performed by fellowship-trained hand surgeons and orthopedists, no evaluation of interobserver variability was performed. Furthermore, although data collection and analysis

Table 2. Characteristics of patients with persistent median artery (n=9)

Patient no	Sex	Age	Side	PMA location	Management	Intraoperative complications	Postoperative complications
1	F	47	R	Superficial	Preserved	None	None
2	M	55	L	Deep	Preserved	None	None
3	F	49	R	Superficial	Preserved	None	None
4	F	61	L	Superficial	Preserved	None	None
5	M	50	L	Deep	Preserved	None	None
6	F	52	R	Superficial	Preserved	None	None
7	M	58	R	Deep	Preserved	None	None
8	F	44	L	Superficial	Preserved	None	None
9	F	53	R	Superficial	Preserved	None	None

PMA: Persistent median artery

were carried out by two independent raters, no statistical measure of interrater reliability (e.g., Cohen's kappa) was calculated, thereby weakening the claim that bias was minimized. However, the large cohort size and consistent surgical technique used across multiple anesthesia modalities by experienced surgeons increase the generalizability of our results. Our study also provides valuable epidemiological data from the Middle Eastern population, contributing to the geographic diversity of the PMA prevalence literature.

Conclusion

This study shows that PMA is a rare anatomic variant encountered during open CTR and has a prevalence of 0.9% in our series. This relatively low rate likely reflects the limitations of intraoperative detection in the absence of imaging support. Although rare, the PMA remains a surgically important structure due to its close relationship with the median nerve and its potential contribution to hand vascularization. Recognizing this variation and adapting surgical technique accordingly may help minimize complications and ensure safe surgical outcomes.

Ethics

Ethics Committee Approval: This retrospective study was conducted after obtaining internal ethical approval from the Selçuk University Rectorate Local Ethics Committee and in accordance with the principles outlined in the Declaration of Helsinki (approval no: 2025/329, date: 03.06.2025).

Informed Consent: This retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: E.S.E., M.E., A.Ö., Concept: E.S.E., M.E., A.Ö., Design: E.S.E., A.Ö., Data Collection or Processing: E.S.E., Analysis or Interpretation: E.S.E., M.E., A.Ö., Literature Search: E.S.E., Writing: E.S.E., M.E., A.Ö.

Conflict of Interest: The authors declared no conflict of interest.

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