RESEARCH ARTICLE

A Prospective Evaluation of the Prevalence of Persistent Median Artery in Patients with Carpal Tunnel Syndrome

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Abstract

Background: The median artery is an embryonic structure that typically regresses during gestation. Occasionally, the artery remains and is then termed a persistent median artery (PMA). A PMA can be associated with other anatomic anomalies, and has been known to contribute to carpal tunnel syndrome (CTS). Recent literature has observed an increase in PMA prevalence, speculated to indicate microevolutionary change. We performed a prospective observational study to investigate the current prevalence rate of PMA in patients undergoing carpal tunnel release (CTR).

Methods: Institutional review board approval was obtained. From October 2020 to January 2021, patients ≥18 years old undergoing open CTR by 9 orthopaedic hand surgeons were included in analysis. Patients undergoing endoscopic CTR were excluded. Intraoperatively, the carpal tunnel was evaluated for the presence of a PMA, median nerve anomalies, or any other anatomic anomalies. If a patient underwent bilateral CTR during the study, only one side was included in analysis as determined randomly.

Results: Three hundred and sixty open CTRs in 327 patients were performed during the study. Twenty-seven PMAs were identified, for an overall prevalence rate of 8.3%. The average age of patients with a PMA was 63.6 years (SD 13.3 years), consisting of 15 men and 12 women. There were no statistical differences in age, gender, or laterality between patients that did and did not have a PMA. Thirty-three patients underwent bilateral CTR during the study, with 3 being found to have a PMA unilaterally, and zero having a PMA bilaterally. Two bifid median nerves (0.6%) were also identified.

Conclusion: This study represents the highest prevalence rate of PMA directly observed in CTR patients reported to date (8.3%). A PMA is not a rare finding, and it should be recognized and protected during CTR. Occasionally, a PMA can be the cause of an acute presentation of CTS.

Level of evidence: IV

Keywords: Carpal tunnel, Carpal tunnel syndrome, Median artery, Persistent median artery, Wrist anatomy

Introduction

The median artery is an embryonic structure which comprises the arterial axis of the forearm in early embryogenesis. It typically regresses during the first several months of gestation as the radial and ulnar arteries develop. In some embryos, the artery remains and is termed a persistent median artery (PMA). There are two subtypes: the antebrachial type, representing partial axial artery regression and is usually of narrow caliber and limited to the forearm, and the palmar type, which traverses through the carpal tunnel accompanying

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the median nerve, possibly joining with the hand vasculature in a variety of patterns.[1]

A PMA can be associated with median nerve anomalies such as bifid median nerve and high divisions.[2,3] A PMA can also contribute to vascular perfusion, possibly joining with the ulnar artery in the superficial palmar arch, or independently forming common digital arteries.[1,4,5] The clinical significance of a PMA is wide ranging. It has been speculated to be a potential cause of carpal tunnel syndrome (CTS), particularly when a larger diameter vessel is present.[2, 6-8] Median compressive neuropathy has also been associated with atherosclerosis, thrombosis, calcifications, and trauma to a PMA.[9-12]

Most of the data evaluating the prevalence of PMA are derived from cadaveric studies or case reports.[13] Authors of a recently published and widely publicized cadaveric study concluded that the prevalence rate of PMA has tripled compared to that of historic data, from about 10% of people born in the late 1800s to about 30% of people born in the late 1900s, and speculated this finding indicated a microevolutionary change.[13,14] However, the heterogeneity of these cadaveric studies and paucity of studies in live subjects make these results difficult to extrapolate to current hand surgery practice. The purpose of this study is to investigate the current prevalence rate of PMA in patients undergoing carpal tunnel release (CTR) surgery. Given the reportedly increased prevalence of PMA over the last century, we hypothesized that the observed prevalence rate of PMA in our study would be higher than that of earlier studies reporting the prevalence of PMA in patients undergoing CTR.

Materials and Methods

Institutional review board approval was obtained prior to beginning this study. This was a prospective observational study seeking to identify the prevalence of PMA in patients undergoing open CTR from October 2020 to January 2021. Inclusion criteria included patients ≥18 years old undergoing open CTR at our institution. Nine fellowship trained orthopaedic hand surgeons contributed patients to this study. After releasing the transverse carpal ligament in each patient, surgeons evaluated the carpal tunnel for presence of a PMA. The surgeon inspected the median nerve, and the surrounding flexor tendons to ensure presence or absence of a PMA. If a PMA was observed, the surgeons also noted whether the PMA was thrombosed or inflamed, whether there was a median nerve anomaly, and any other anatomic anomalies. Patients undergoing endoscopic carpal tunnel release were excluded from this study to ensure there was adequate visualization of carpal tunnel components in each included case. If a patient underwent bilateral carpal tunnel release during the study period, only one side was included in analysis as determined randomly. Continuous data is presented as mean and standard deviation and analyzed with independent t-test. Categorical data is presented as counts and percentages and analyzed with Chi-Square testing. Statistical significance was set at $P < .05$.

Results

Three hundred and sixty open carpal tunnel releases in 327 patients were performed by the participating surgeons during the study period. Thirty-three patients underwent bilateral carpal tunnel release during the study period. Study patients consisted of 143 men (43.7%) and 184 women (56.3%), with an average age of 62.3 years (SD 14.2).

Twenty-seven PMAs were identified in the 327 patients, for an overall prevalence rate of 8.3% [Figure 1, Table 1]. The average age of patients with a PMA was 63.6 years (SD 13.3 years), consisting of 15 men (55.6%) and 12 women (44.4%). There were no statistical differences in age, sex, or laterality between patients that did and did not have a PMA (*P>0.05*) [Table 2]. Of the 33 patients who underwent bilateral carpal tunnel release, 3 were found to have a PMA unilaterally. No patients who underwent

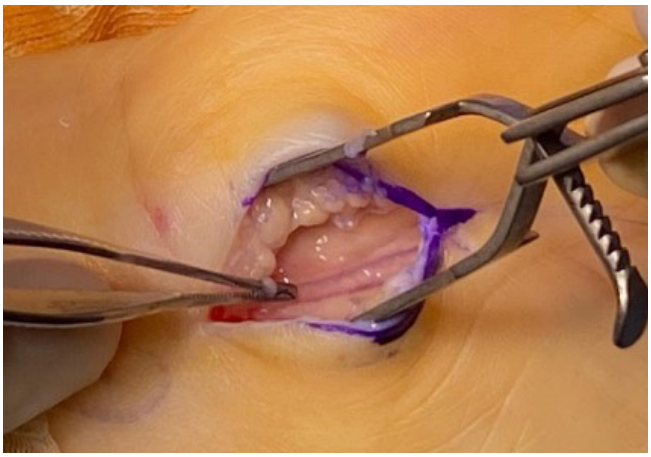

Figure 1. A persistent median artery observed in a carpal tunnel release patient (distal at right of image).

Table 1. Anatomic anomalies identified within the carpal tunnel

Anatomic Anomaly	N (%)
Persistent median artery	27 (8.3%)
Bifid median nerve	2 (0.6%)

Table 2. Demographics of patients that did and did not have a persistent median artery

	PMA Present (N=27)	PMA Absent (N=300)	*P value*
Age [mean (SD)]	63.6 (13.3)	62.1 (14.2)	0.628
Gender % (N)			0.196
Male	55.6 (15)	42.7 (128)	
Female	44.4 (12)	57.3 (172)	
Laterality % (N)			0.432
Left	51.9 (14)	44.0 (132)	
Right	48.1 (13)	56.0 (168)	

Legend: PMA = persistent median artery

bilateral carpal tunnel release were found to have bilateral PMA.

No patients had a thrombosed or visibly inflamed PMA. A bifid median nerve was identified in two patients (0.6%). One of the patients with a bifid median nerve was also found to have a PMA, and the other patient did not have a PMA. No other anatomic anomalies were identified in the study patients.

Discussion

We identified the presence of a PMA in 8.3% of patients undergoing open CTR. The majority of literature on PMA prevalence are cadaveric studies, with very few studies having investigated the prevalence of PMA in live subjects.[6, 13, 15-18] PMA prevalence rates reported in live subjects undergoing CTR have ranged from 0.6-4.4%. Chalmers et al. reported a PMA prevalence rate of 4.4% in 228 CTR patients, when looking for "large" PMAs.[17] Similarly, Barfred et al. and Lindley et al. reported PMA rates of 2.4% and 3.4%, respectively, in patients undergoing CTR.[6, 18] Bilgin et al. observed a PMA in 1.3% of 313 CTRs in a Turkish population.[16] In a similar study, Ahn et al. reported the lowest published PMA prevalence rate in live subjects undergoing CTR at 0.6% in a Korean population.[15] While some of the prior studies conducted on live patients had size requirements for the PMA which could have underestimated their results, our study found a higher rate of PMA when compared to prior studies. This may coincide with claims made by Lucas et al. indicating microevolutionary changes with respect to the presence of the PMA.[13]

By analyzing the PMA prevalence rates of 42 cadaveric studies, Lucas et al. concluded that the prevalence of PMA has nearly tripled since the late 19th century, which is believed to indicate microevolutionary change.[13] Based on their models, the PMA prevalence rate of individuals born in the 1950s, which is the average birth year of patients in our study, should be approximately 20%. We sought to observe the current incidence of PMA in our patients undergoing open carpal tunnel release. By understanding the prevalence of PMA in our current patient population, it afforded an opportunity to compare our results to those found in previous studies.

Having a PMA is a historical risk factor for the development of CTS. Therefore it is intuitive that the observed prevalence of PMAs in CTR patients would likely be higher than that observed in cadaveric studies. The presence of a PMA may limit the space within the carpal tunnel and can contribute to the typical gradual presentation of CTS.[18] A thrombosed or acutely injured PMA can alternatively cause an acute presentation of CTS.[6,18] No PMA patients in our study had an acute presentation of CTS, and no patients were found to have a thrombosed PMA intraoperatively.

The presence of a PMA has been previously associated with other anatomic anomalies within the carpal tunnel, such as bifid median nerve.[15,18] We observed 2 cases (0.6%) of bifid median nerve in our cohort, one of which was associated with PMA. Our findings are comparable to previously published studies with rates ranging from 1.0 – 6.1%, which have reported a bifid median nerve occurring both with, and in the absence of, a PMA.[18-21] Anatomic anomalies within the carpal tunnel has also been evaluated using magnetic resonance imaging (MRI). In a retrospective MRI investigation, Pierre-Jerome et al. reported a PMA prevalence rate of 11% and bifid median nerve rate of 6.1% bifurcating proximal to the carpal tunnel.[20]

The strengths of our study include its prospective design and large sample size, and thus the significance of the PMA prevalence rate reported here. All included CTRs were performed open, which ensured adequate visualization of the carpal tunnel components in each case. Weaknesses of our study include that we did not specify the anatomic location or measure the diameter of the PMA. Our data was collected by 9 surgeons who likely have slight variations in their incisions, however direct visualization of the carpal tunnel components was achieved in all cases. The open CTR incision utilized in our observational study differs from cadaveric studies that utilized extensile approaches extending from the brachium to the level of the palmar arch. Our cohort consisted of patients from a single academic institution in a single region of the United States, which could limit the generalizability of the results. This study did not analyze PMA rates based on patient race, and it is possible that PMA prevalence could vary between different races or populations. Lastly, given the low rate of median nerve anomalies observed in this study, we are unable to form any conclusions regarding any association between median nerve anomalies and the presence of a PMA.

This study represents the highest prevalence rate of persistent median artery directly observed in carpal tunnel release patients reported to date. A PMA is not a rare finding, and it should be recognized and protected during carpal tunnel release. Lastly, in the setting of acute carpal tunnel syndrome, a PMA should be considered as a potential contributing factor.

Disclosure: The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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