**Review**

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# Review of extraosseous and intraosseous blood supply of the carpal bones

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**Abstract**

The blood supply of the carpal bones has been updated and described with new dissection, vascular filling and imaging techniques. It is very important to know the vascular anatomy of the carpal bones in order to predict vascular insufficiency and associated avascular necrosis that may occur as a result of any injury such as fracture. This article reviews the extraosseous and intraosseous vascular supply of the carpal bones. The carpal bones are supplied by three vascular arches formed by the radial, ulnar and anterior interosseous arteries on the dorsal and palmar sides of the wrist. These contribute to the dorsal and palmar carpal vascular systems, which consist of transverse arteries connected by longitudinal anastomoses. The scaphoid and capitate have a high risk of avascular necrosis, while the trapezium, triquetrum, pisiform and 80% of the lunate have a lower risk. With the development of new imaging techniques, new information is added to the literature. With the increase in three-dimensional studies, intraosseous vascularity and its correlation with carpal bone fractures and its relationship with avascular necrosis will be revealed more clearly.

**Keywords:** arterial supply; carpal bone; extraosseous vascularity; intraosseous vascularity; vascular anatomy

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## Introduction

The vascularity of the carpal bones has been updated and defined until today with new dissection, vascular filling and imaging techniques. It is essential to know the vascular anatomy of the carpal bones in order to predict vascular failure and the resulting avascular necrosis, that may occur as a result of any damage such as fractures. This article reviews the extraosseous and intraosseous vascular supply of the carpal bones.

## Extraosseous Vascularity of the Carpal Bones

The carpal bones are supplied by three vascular arches each on the dorsal and palmar sides of the wrist, formed by the radial, ulnar and anterior interosseous arteries (**Figure 1**). They contribute to the dorsal and palmar carpal vascular systems, which consist of transverse arteries connected by longitudinal anastomoses. The arches on the dorsal side are the dorsal radiocarpal, dorsal intercarpal and basal metacarpal. On the palmar side, there are palmar radiocarpal, palmar intercarpal and deep palmar arches.[1]

After the brachial artery divides into radial and ulnar arteries, the radial artery first gives the radial recurrent artery in the proximal part of the forearm. Then, radial artery gives palmar carpal branch. The palmar radiocarpal and intercarpal arches are formed by anastomosing with the palmar carpal branch of the radial artery and the common interosseous artery and palmar carpal branch of the ulnar artery. The palmar radiocarpal arch is located more proximally and is generally formed by radial, ulnar and anterior interosseous arteries, and its variations are few. It extends transversely proximal to the radiocarpal joint. The palmar intercarpal arch extends transversely between the proximal and distal rows of carpal bones, and its variations are common.[1–3]

The dorsal radiocarpal arch is the most proximal of the dorsal carpal network and occurs deep to the extensor muscle tendons at the level of the radiocarpal joint. Although this network is formed by radial, ulnar and anterior interosseous arteries, there are variations in which ulnar and anterior interosseous arteries do not participate. The dorsal intercarpal arch runs between the proximal and distal rows of carpal bones. It is the largest of the three

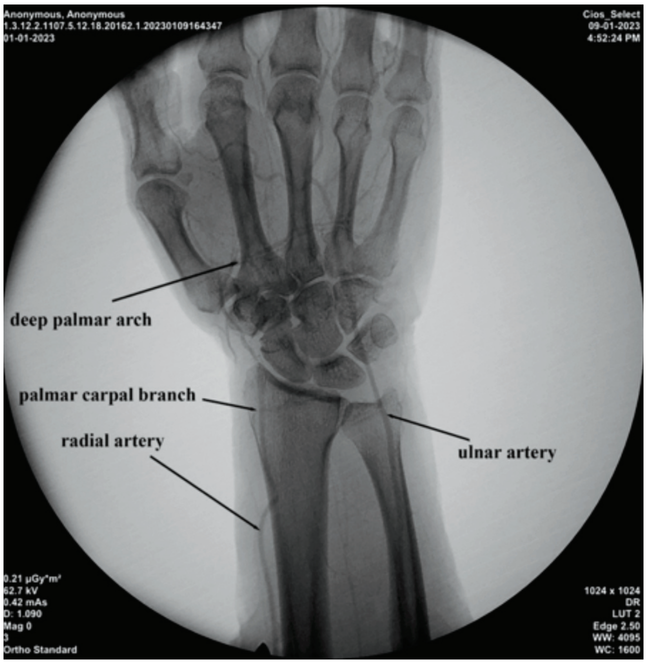


**Figure 1.** C-arm scopy image of main arteries responsible for supplying the carpal bones.

dorsal arches. It anastomoses with the dorsal radiocarpal arch to supply the lunate and triquetrum. The distal or basal metacarpal arch runs along the bases of the metacarpal bones, just distal to the carpometacarpal joint, and is the smallest of the dorsal arches. It can also anastomose with the perforating branches of the deep palmar arch in the 2nd, 3rd and 4th interosseous spaces. Dorsal arches are connected to each other by longitudinally extending branches.[1,4]

Dorsal intercarpal, palmar radiocarpal and deep palmar arches can always be seen in humans, while dorsal radiocarpal arch is seen in 80%, basal metacarpal arch is seen in 27%, and palmar intercarpal arch is seen in 53%. Most carpal bones are fed by branches coming from these arches. As an exception, the dorsal and lateral aspects of the trapezium and the scaphoid are also supplied by branches coming directly from the radial artery, and the pisiform and triquetrum are fed by branches coming directly from the ulnar artery.[1]

## Intraosseous Vascularity of the Carpal Bones

Gelberman and Gross[5] classified the carpal bones for risk of avascular necrosis according to their intraosseous vascular pattern. According to them, scaphoid, capitate and the 8–10% of the lunate are located in the group 1. These bones have highly risk of avascular necrosis. Group 2 consists of trapezoid and hamate and, group 3 has trapezium, triquetrum, pisiform and 80% of lunate (**Table 1**).

### Scaphoid

The scaphoid is the most common fractured carpal bone. Avascular necrosis is seen especially after proximal pole fractures. The scaphoid receives arteries mainly from radial artery. The palmar carpal branch of the radial artery supplies the proximal part, superficial palmar branch of the radial artery supplies the middle and distal part of the palmar surface. On the dorsal surface, the dorsal scaphoid artery that a branch of the radial artery supplies the scaphoid. This artery usually anastomoses with the dorsal branch of the anterior interosseous artery.[6,7]

The intraosseous vascularity of the scaphoid dependent to single artery which supplies major part of the bone. On the dorsal side, one artery enters the bone from dorsal ridge and supplies the proximal 70–80% of the bone, while the other artery enters to the bone from the tubercle on the palmar side and supplies the distal 20–30% of the bone.[6,8–14] According to Gelberman and Gross,[5] and, Gelberman and Menon,[6] the scaphoid has a high risk of avascular necrosis because it consists of large areas of bone containing single intraosseous artery and there is no anastomosis between the arteries supplying different areas. However, according to the study by Morsy et al.[8] analyzing the intraosseous vascularity of the scaphoid by micro-computed tomography, there is anastomosis between the vessels located proximal and distal to the bone in 15% of cases and some scaphoids have better perfusion than others.

While, according to Gelberman and Gross,[5] and, Gelberman and Menon,[6] and Taleisnik,[10] the vessels at the attachment of the scapholunate ligament on the dorsal side does not contribute to the intraosseous vascularity, Morsy et al.[8] and Xiao et. al.[15] showed that the

**Table 1**
Classification of carpal bones according to the risk of avascular necrosis due to intraosseous vascular pattern.

| Group 1 | Group 2 | Group 3 |
|---|---|---|
| Scaphoid | Trapezoid | Trapezium |
| Capitate | Hamate | Triquetrum |
| Lunate (8–20%) | | Pisiform |
| | | Lunate (80–92%) |

entrance of the vessels located at the attachment of the scapholunate ligament to inside the bone.

## Capitate

The capitate receives blood supply from dorsal intercarpal, basal metacarpal, palmar intercarpal arches and recurrent branches of the ulnar artery. On the dorsal side, 2–4 vessels enter to the bone from concave part of it. Vessels entering from distal half of the bone run retrogradely and supply the head and body of the bone. Vascular supply of the head of the bone is provided by 1–3 vessels entering to the bone on the palmar side. There is 30% anastomosis between palmar and dorsal vessels. The proximal pole of the capitate has rich vascularity, while the articular surface has poor vascularity.[11] Kadar et al.[11] and Xiong et al.[12] used micro-computed tomography to identify a vessel directly supplying this pole in the proximal part of the capitate in 70% of the cases. It may explain why most capitate waist fractures do not progress to proximal pole avascular necrosis. Xiong et al.[12] also reported that the main vascular branches supplying the capitate originate from around the ligaments.

## Trapezoid

The trapezoid receives vascular supply from intercarpal and basal metacarpal arches and recurrent branches of the radial artery. The 3–4 vessels entering the bone from the dorsal side are responsible for 70% of the vascularization of the bone. The 1–2 vessels entering the bone from the palmar side are responsible for 30% of the vascularization of the bone. There is no anastomosis between dorsal and palmar vessels.[13]

## Hamate

The hamate receives vascular supply from dorsal intercarpal arch, terminal branches from anterior interosseous artery and recurrent branches of the ulnar artery. 3–5 vessels entering from dorsal surface supply the 30–40% of the bone. On the dorsal surface, vessels entering into bone from the lateral surface of the hook of hamate are responsible major intraosseous vascularization of the hamate. These vessels anastomose with dorsal vessels at a rate of 50%.[13,14] In the micro-computed tomography studies of Xiao et al.,[9] the number of arteries in the dorsal region was found to be higher, indicating that the blood circulation in the dorsal region may be more dominant. According to Panagis et al.[13] 1–2 vessels entering from the medial surface of the hamate hook do not anastomose with other vessels, whereas Wang et al.[16] defined anastomosis between the vessels in the body and hook in their studies performed with micro computed tomography. The lack of direct vascular supply to the proximal part of the bone predisposes to avascular necrosis.[13,15,16]

## Lunate

The lunate receives vascular supply from radiocarpal and intercarpal arches, dorsal and palmar branches of the anterior itnterosseous artery and, recurrent branches of the ulnar artery.[13,17] Dubey et al.[18] described the foramina of the bone surface and identified that palmar foramina are wider than dorsal. Van Alphen et al.[19] analyzed the diameter of the vessels in their studies performed with micro computed tomography and found that palmar vessels were wider than dorsal.[18,19] While in 80% of the lunate, nutrient vessels enter the bone from palmar and dorsal surfaces, in 20% of lunate they enter from only palmar surface. This pattern may explain that some lunate bones prone to Kienböck's disease which is idiopatic avascular necrosis of the lunate. For 80% of the lunate, dorsal and palmar interosseous vessels anastomose each other. According to the distribution of the interosseous vessels, the lunate is classified in 3 patterns; Y, I and X. Y is the most common pattern and X is the least common pattern.[13,19]

## Triquetrum

Triquetrum is supplied from the dorsal and palmar sides by small branches from the dorsal intercarpal, dorsal radiocarpal and palmar radiocarpal arches and, ulnar artery.[1] In 2023, the vascular foramina of the triqetrum were described and suggested that the arterial supply of the triquetrum mainly provide by vessels entering dorsal surface.[20] In other studies which examine vessels with vascular filling, it has been reported that 2–4 vessels entering from the protrusion on the dorsal side nourish the dorsal 60% of the bone, and 1–2 vessels entering from the proximal and distal sides of the palmar side where it articulates with the pisiform nourish the palmar 40% of the bone. Vascular anastomoses are present on the dorsal and palmar sides.[13,21] Triquetrum is included in the group of carpal bones with low risk of avascular necrosis because there is no single artery dominance in its nutrition and the vessels anastomose within the bone.[5] Although avascular necrosis is rare, it is usually observed after trauma.

## Pisiform

The proximal part of the pisiform is supplied by dorsal carpal branch of the ulnar artery; the distal part is supplied by branches of the deep palmar arch and the lateral part is supplied by directly branches of the ulnar artery. While proximal vessels enter the bone from attachment area of the tendon of the flexor carpi ulnaris, distal vessels enter from below the articular surface with triquetrum.[13,22]

### Trapezium

The trapezium receives 1–3 vessel on the dorsal side, 1–3 vessel on the palmar side and 3–6 vessel on the lateral side from distal branches of the radial artery. There is anastomosis between these vessels. Dorsal intraosseous vascular pattern is dominant.[13]

## Conclusion

It is important to know how the blood supply of a bone because when a bone is fractured, it can show a union depending on this blood supply pattern. Avascular necrosis usually occurs after nonunion and results in the death of bone and bone marrow cells due to decreased bone vascularity and eventually mechanical failure. The scaphoid and capitate have a high risk of avascular necrosis, while the trapezium, triquetrum, pisiform, and 80% of lunate have a lower risk. With the development of new imaging techniques, new information is being added to the literature. With the increase in three-dimensional studies, intraosseous vascularity and its correlation with carpal bone fractures and its relationship with avascular necrosis will be revealed more clearly.

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### Conflict of Interest

This study declares no conflicts of interest.

### Ethics Approval

The methods employed in this study followed the ethical guidelines established by the institutional research committee and were in accordance with the principles outlined in the 1964 Helsinki Declaration and its subsequent amendments.

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## References

1. Gelberman RH, Panagis JS, Taleisnik J, Baumgaertner M. The arterial anatomy of the human carpus. Part I: the extraosseous vascularity. J Hand Surg Am 1983;8:367–75.
2. Standring S. Gray's anatomy: the anatomical basis of clinical practice. 42nd ed. China: Elsevier Health Sciences; 2021. 1584 p.
3. Doyle JR. Orthopaedic surgery essentials. Hand & wrist. Baltimore (MD): Lippincott Williams & Wilkins; 2006. p. 259.
4. Freedman DM, Botte MJ, Gelberman RH. Vascularity of the carpus. Clin Orthop Relat Res 2001;(383):47–59.
5. Gelberman RH, Gross MS. The vascularity of the wrist. Identification of arterial patterns at risk. Clin Orthop Relat Res 1986;(202):40–9.
6. Gelberman RH, Menon J. The vascularity of the scaphoid bone. J Hand Surg Am 1980;5:508–13.
7. Oehmke MJ, Podranski T, Klaus R, Knolle E, Weindel S, Rein S, Oehmke HJ. The blood supply of the scaphoid bone. J Hand Surg Eur Vol 2009;34:351–7.
8. Morsy M, Sabbagh MD, van Alphen NA, Laungani AT, Kadar A, Moran SL. The vascular anatomy of the scaphoid: new discoveries using micro-computed tomography imaging. J Hand Surg Am 2019; 44:928–38.
9. Xiao Z, Xiong G, Zhang W. New findings about the intrascaphoid arterial system. J Hand Surg Eur Vol 2018;43:1059–65.
10. Taleisnik J. The ligaments of the wrist. J Hand Surg Am 1976;1:110–8.
11. Kadar A, Morsy M, Sur YJ, Laungani AT, Akdag O, Moran SL. The vascular anatomy of the capitate: new discoveries using micro-computed tomography imaging. J Hand Surg Am 2017;42:78–86.
12. Xiong G, Xiao ZR, Zhang WG. Vascular anatomy of the capitate determined by micro-computed tomography angiography. J Hand Surg Eur Vol 2017;42:966-7.
13. Panagis JS, Gelberman RH, Taleisnik J, Baumgaertner M. The arterial anatomy of the human carpus. Part II: the intraosseous vascularity. J Hand Surg Am 1983;8:375–82.
14. Rozen WM, Niumsawatt V, Ross R, Leong JC, Ek EW. The vascular basis of the hemi-hamate osteochondral free flap. Part 1: vascular anatomy and clinical correlation. Surg Radiol Anat 2013;35:585–94.
15. Xiao ZR, Zhang WG, Xiong G. Features of intra-hamate vascularity and its possible relationship with avascular risk of hamate fracture. Chin Med J (Engl) 2019;132:2572–80.
16. Wang DY, Li X, Shen ZC, Gu PL, Pei YR, Zeng G, Leng HJ, Zhang WG. Three-dimensional architecture of intraosseous vascular anatomy of the hamate: a micro-computed tomography study. [Article in Chinese] Beijing Da Xue Xue Bao Yi Xue Ban 2018;50:245–8.
17. Lamas C, Carrera A, Proubasta I, Llusà M, Majó J, Mir X. The anatomy and vascularity of the lunate: considerations applied to Kienböck's disease. Chir Main 2007;26:13–20.
18. Dubey PP, Chauhan NK, Siddiqui MS, Verma AK. Study of vascular supply of lunate and consideration applied to Kienböck disease. Hand Surg 2011;16:9–13.
19. van Alphen NA, Morsy M, Laungani AT, Kadar A, Vercnocke AJ, Lachman N, Ritman EL, Moran SL. A three-dimensional micro-

computed tomographic study of the intraosseous lunate vasculature: implications for surgical intervention and the development of avascular necrosis. Plast Reconstr Surg 2016;138:869e–78e.

20. Balci A, Yildiran G, Kendir S, Karahan ST, Apaydin N. The morphologic and morphometric features of the triquetrum. Hand Surg Rehabil 2023;42:40–4.
21. Grettve S. Arterial anatomy of the carpal bones. Acta Anat (Basel) 1955;25:331–45.
22. Canovas F, Prudhomme M, Bonnel F. Circular arterial supply of the pisiform bone. Acta Anat (Basel) 1996;157:159–63.
23. Iwanaga J, Singh V, Takeda S, Ogeng'o J, Kim HJ, Moryś J, Ravi KS, Ribatti D, Trainor PA, Sañudo JR, Apaydin N, Sharma A, Smith HF, Walocha JA, Hegazy AMS, Duparc F, Paulsen F, Del Sol M, Adds P, Louryan S, Fazan VPS, Boddeti RK, Tubbs RS. Standardized statement for the ethical use of human cadaveric tissues in anatomy research papers: recommendations from anatomical journal editors-in-chief. Clin Anat 2022;35:526–8.

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