Incidence of Acute Vascular Injury Associated with Fracture Distal Radius

Asmaa Hosny Mohamed*[1], Mostafa M. Nabeeh[2], Barakat El-Alfy[3], Samir M. Attia[4]
Departments of [1]Emergency Medicine, [2]Neurosurgery, [3]Orthopedic Surgery and [4]Vascular Surgery, Faculty of Medicine, Mansoura University, Egypt
***Corresponding Author**: Asmaa Hosny Mohamed, **Mobile**: (+20) 01068209026, **Email**: asmaahosny935@gmail.com

ABSTRACT
Background: One of the most frequent forms of fractures observed in emergency rooms are distal radius fractures (DRF). Radial or ulnar artery lacerations caused by distal radius or ulnar fractures are uncommon injuries. Vascular problems, formerly thought to be uncommon in connection with distal radius fracture, may be more often identified by volar exposures.
Objective: This study aimed to assess the incidence of acute vascular injury associated with fracture distal radius and its impact on short term outcomes.
Patients and Methods: This observational study involved 100 patients with distal radius fractures in total. During the local examination, the kind of fracture—open or closed—was determined as well as the state of the wounded arteries by vascular evaluation and radiological exams, which included X-rays. The evaluation of the hand's vascular health was one of the study's primary outcomes.
Results: There was a statistically significant correlation between the injured side and the presence of acute vascular damage related to distal radius fracture. Regarding the method of trauma and soft symptoms, there was no statistically significant difference between those with and without acute vascular injury. In cases when a distal radius fracture was present together with an acute vascular injury, limb salvage was statistically more often than in cases where it wasn't.
Conclusion: There was a significant relation between presence of acute vascular injury and fracture distal radius.
Keywords: Acute Vascular Injury, Fracture Distal Radius, Vascular complications.

INTRODUCTION

Distal radius fractures (DRF) are one of the fracture forms that are most frequently seen in emergency rooms, accounting for as much as eighteen percent of all fractures in people over 65 years old and as much as twenty-five percent of fractures in the pediatric population [1]. The majority of instances of pseudoaneurysms linked with vascular injuries (radial or ulnar artery) with distal radius fracture were surgically produced and resulted from internal or external fixation implants [2,3].

Radial or ulnar artery lacerations caused by distal radius or ulnar fractures are uncommon injuries [4]. While it is clear how to treat detached radial or ulnar artery injuries with the indication of treating (conservatively or surgically) an isolated DRF, it is unclear what the best course of action is when a distal radius fracture is present along with a lacerated radial artery. When the hand exhibits normal function prior to surgery, there is no difference between the two surgical techniques regarding "cold" sensitivity symptoms. The two modalities of vascular treatment are reconstruction of the artery or ligation [2].

Vascular problems, which were long thought to be uncommon in connection with distal radius fractures, may now be recognized more frequently as volar exposures become more common. Identification of these injuries is unlikely to have an impact on the functional outcome or result since the majority of single artery injuries in the wrist and forearm are not linked to ischemia. Arterial reconstruction may be required in the unique patient who has a dysvascular hand following a distal radius fracture [5].

Distal radius fractures are among the most frequent injuries treated in emergency rooms, but when they are coupled with radial artery lacerations, they present a particularly special set of challenges for both diagnosis and management of the patient's care. Despite the fact that several reports in the literature describe the vascular complications of the radial artery following surgical therapy of the distal radius fracture. While the protocol of therapy has been elucidated for solitary DRF, it is still uncertain when the fracture is connected to a radial artery lesion [2].

This study aimed to assess the incidence of acute vascular injury associated with fracture distal radius and its impact on short term outcomes.

PATIENTS AND METHODS

This was an observational study conducted on a total of 100 patients with fracture distal radius who were admitted to Emergency Hospital, Faculty of Medicine, Mansoura University within the period from May 2022 to May 2023. We included patients with any age with fracture distal radius either with or without vascular affection but we excluded any patient with history of vascular injury in the affected forearm.

Methods

All patients were subjected to primary survey and resuscitation that included airway maintenance and cervical spine immobilisation in cases with cervical injury, endotracheal intubation if needed and mechanical ventilation, control of hemorrhage by intravenous fluids and vasopressors if needed, management of coma by coma's cocktail (Dextrose,

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thiamine and naloxone), and management of convulsion by antiepileptic measures (intravenous benzodiazepine). Age, sex, residency, previous surgical history, and medical condition history were all part of the thorough history-taking process. A comprehensive clinical examination included a general check-up (pulse, blood pressure, temperature, respiratory rate), a local check-up that included determining the type of fracture—either open or closed—and the grades of open fractures, as well as a vascular assessment to assess the condition of the arteries (intact, partial, complete, or thrombosis).

Investigations

Laboratory investigations included CBC, INR, blood grouping, and serum creatinine while radiological examinations included X-rays, duplex ultrasound, and CT angiography.

Outcomes

The assessment of the hand's vascular status, which included capillary refill time, signs of distal ischemia, visible expanding hematomas, significant hemorrhages discovered during history taking, a decreased pulse compared to the contralateral extremity, bony injury or nearby penetrating wounds, neurologic abnormalities, and complaints of vascular dysfunction (hard and warm signs), were the study's main findings. While objective indicators of vascular injury were audible bruit over or close to the artery by auscultation, arterial thrill (i.e., vibration) by manual touch, and witnessed pulsatile hemorrhage.

These symptoms were used to identify patients who needed surgery. Low systemic blood pressure may be the cause of cool, cold, and pulseless extremities, but isolated pulse abnormalities and significant side-to-side variation in pulse quality are clear signs of underlying proximal vascular damage. It is more likely that an extremity vascular damage has occurred when there are neurologic deficits, delayed capillary refill, and bone abnormalities, necessitating an urgent arteriography or surgical investigation and repair.

Ethical Consideration

Before beginning the study, the IRB of the Mansoura University Faculty of Medicine granted its clearance. The study purpose and objectives were made clear to the subjects by the researcher. The researcher guaranteed that the subjects' data would remain anonymous and private. The subjects were made aware of their right to decide whether or not to participate in the study and that they could do so at any moment and without providing a justification. Subjects' ethics, values, cultures, and beliefs were honoured. Every adult patient or caregiver of every child patient gave a written consent to participate in the study. The Helsinki Declaration was followed throughout the study's conduct.

Statistical Analysis

SPSS software, version 25 (SPSS Inc. Chicago, PASW statistics for Windows version 25), was used to analyze the data. Number and percentage were used to describe qualitative data, which were compared by Monte Carlo, Fisher exact, and Chi-square tests. Median (min and max) for non-normally distributed data was used to explain quantitative data, which were compared by Mann Whitney U test. Following the Kolmogorov-Smirnov test for normality, mean and standard deviation (SD) were used to represent quantitative data that are regularly distributed and which were compared by the independent student t test. The acquired results' significance was assessed at the (0.05) level.

RESULTS

According to **Table 1**, the average age of the cases under study was 36.94±16.19. 51% of the cases were females, 51% of the cases were from urban areas, 25% of the cases had diabetes, and 30% were hypertensive patients. In addition, 52% of the cases under study had left hand affection; 90% had open fractures; and 52% had concomitant non-skeletal injuries. Glasgow Coma Scale ranged from 8 to 15, the mean heart rate was 74.55 beats per minute (bpm), the mean arterial blood pressure was 90.31 mm Hg, and 21% of the cases under study fell into the AO classification class A3, 17% B1, and 16% A2. Figure 1 shows that 40% of the cases under study involved falling from heights.

Table (1): Sociodemographic characteristics, affect side, fracture type, vital signs and AO classification of fracture of the studied cases

	No=100	%
Age (years) Mean ± SD (Min-Max)	36.94±16.19 (11-86)	
Sex Male Female	 49 51	 49.0 51.0
DM no yes	 75 25	 75.0 25.0
Hypertension -ve +ve	 70 30	 70.0 30.0
Myocardial infarction -ve +ve	 92 8	 92.0 8.0
Residence Urban Rural	 51 49	 51.0 49.0
Affected hand Right Left	 48 52	 48.0 52.0
Fracture type Closed Open	 90 10	 90.0 10.0
Associated non skeletal injuries	52	52.0
Glasgow Coma Scale Median (min-max)	14(8-15)	
Heart rate mean±SD	74.55±9.77	
Mean arterial blood pressure mean±SD	90.31±6.29	
AO classification of fracture		
A1	15	15.0
A2	16	16.0
A3	21	21.0
B1	17	17.0
B2	9	9.0
B3	4	4.0
C1	8	8.0
C2	7	7.0
C3	3	3.0

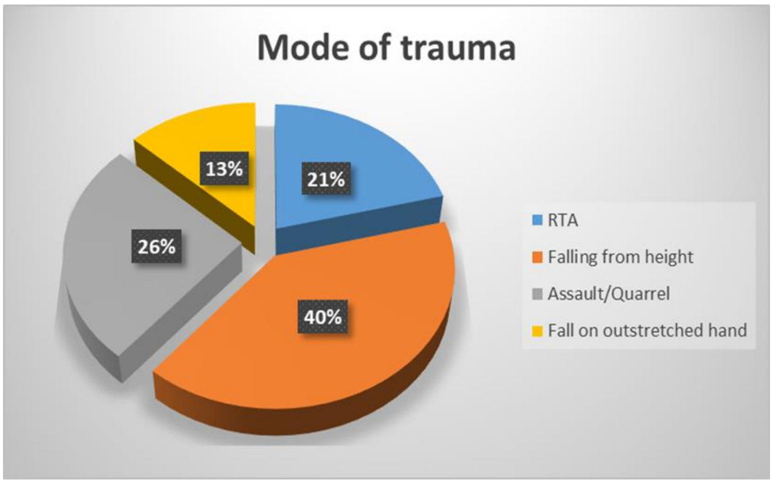

Figure (1): Distribution of the studied cases according to mode of trauma.

Table (2) shows that of the investigated cases, 5% have hard indications, of which 3 cases (60 percent) had ischemia. Seven instances (all with proximity of trauma to an artery) were found to exhibit soft symptoms. **Figure (2)** demonstrates that acute vascular damage occurred in 5% of the cases under study.

Table (2): Studied cases distribution according to frequency of hard signs

	N	%
Hard signs	**5**	**5**
⇒ Hard signs types		
⇒ Pulsatile bleeding	0	0
⇒ Expanding hematoma	2	40
⇒ Ischemia	3	60
✓ Pulselessness	3	60
✓ Pallor	3	60
✓ Pain	2	40
✓ Paresthesia	2	40
✓ Paralysis	2	40
Soft signs	**7**	**7**
⇒ Proximity of trauma to an artery	7	100
⇒ Small non-expanding hematoma	4	57.1
⇒ Reduced pulse	4	57.1
⇒ High risk fracture	3	42.8
⇒ Moderate bleeding at scene	0	0

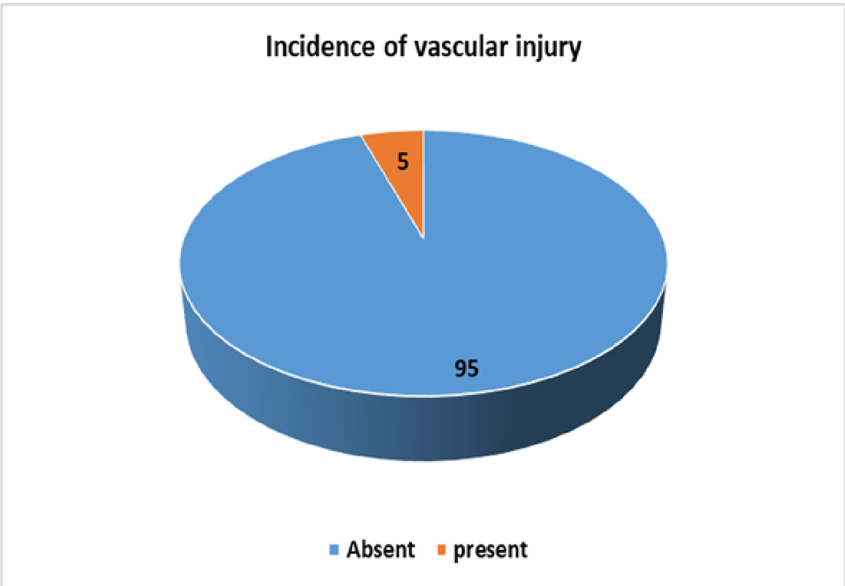

Figure (2): Incidence of vascular injury among studied cases.

Table 3 shows that there was a statistically significant correlation between the occurrence of acute vascular damage in cases with distal radius fracture and the affected side. There was no statistically significant relationship between all other measured parameters and the occurrence of acute vascular injury related to fracture of the distal radius.

Table (3): Relationship between the analyzed cases' sociodemographic details, medical history, affected hand, fracture type, vital signs, and AO classification and the acute vascular injury connected to the fractured distal radius.

	Acute vascular injury associated with fracture distal radius		Test of significance
	-VE N=95(%)	+VE N=5(%)	
Age (years)			
<36	50(52.6)	2(40.0)	χ^{2FET}=0.304
≥36	45(47.4)	3(60.0)	P=0.669
Sex			
Male	45(47.4)	4(80.0)	χ^{2FET}=2.02
Female	50(52.6)	1(20.0)	P=0.200
DM			
no	71(74.7)	4(80.0)	χ^{2FET}=0.07
yes	24(25.3)	1(20.0)	P=1.0
Hypertension			
-ve	66(69.5)	4(80.0)	χ^2=0.251
+ve	29(30.5)	1(20.0)	P=0.617
Myocardial infarction			
-ve	87(91.6)	5(100.0)	χ^2=0.458
+ve	78(8.4)	0	P=0.499
Residence			
Urban	49(51.6)	2(40.0)	χ^2=0.255
Rural	4(48.4)	3(60.0)	P=0.614
Affected hand			
right	43(45.3)	5(100)	χ2=5.70
left	52(54.7)	0	P=0.017*
Fracture type			
Closed	85(89.5)	5(100)	χ^2=0.585
Open	10(10.5)	0	P=1.0
GCS	13.40±1.53	13.0±1.87	t=0.563 p=0.575
Heart rate	74.64±9.76	72.80±10.94	t=0.409 p=0.682
Mean arterial blood pressure	90.46±6.36	87.40±4.51	t=1.06 p=0.291
AO classification			
A1	14(14.7)	1(20.0)	
A2	16(16.8)	0	
A3	19(20)	2(40.0)	
B1	16(16.8)	1(20.0)	
B2	8(8.4)	1(20.0)	Mc=3.73 P=0.881
B3	4(4.2)	1(20.0)	
C1	8(8.4)	0	
C2	7(7.4)	0	
C3	3(3.2)	0	

X^{2FET}: Fisher exact test, χ^2: Chi-Square test, t: T-test, MC: Monte Carlo test, *: Statistically significant

In terms of the method of trauma, **Table (4)** demonstrates that there was no statistically significant difference between cases with and without acute vascular injury, regarding mode of trauma and associated non-skeletal injuries.

Table (4): Relationships among the examined cases between acute vascular injury associated with distal radius fracture and each of trauma type and non-skeletal injuries

	Acute vascular injury associated with fracture distal radius		**Test of significance**
	-VE N=95(%)	+VE N=5(%)	
Mode of trauma RTA Falling from height Assault/Quarrel Fall on outstretched hand	 20(21.1) 37(38.9) 25(26.3) 13(13.7)	 1(20.0) 3(60.0) 1(20.0) 0	MC=1.269 P=0.732
Associated non skeletal injuries	49(51.6)	3(60.0)	$\chi2$=0.135 P=0.713

MC: Monte Carlo test, χ^2: Chi-Square test.

In terms of soft indicators, **Table (5)** demonstrates that hard signs were found more frequently in instances with acute vascular injury than in cases without, by a statistically significant margin. According to **Table (6),** instances with acute vascular injury related to fractured distal radius had a statistically significantly greater incidence of limb salvage than cases without.

Table (5): Relationship between the examined cases' hard and soft symptoms and acute vascular damage related to distal radius fracture

	Acute vascular injury associated with fracture distal radius		**Test of significance**
	-VE N=95(%)	+VE N=5(%)	
Hard signs	0	5(100.0)	χ^2=100 P<0.001*
Soft signs	24(25.3)	3(60.0)	χ^2=2.91 P=0.08

χ^2=Chi-Square test, *: Statistically significant

Table (6): Relation between acute vascular injury associated with fracture distal radius and outcome among the studied cases

	Acute vascular injury associated with fracture distal radius		**Test of significance**
	-VE N=95(%)	+VE N=5(%)	
Limb salvage	94(98.9)	3(60.0)	χ^2=24.76 P<0.001*
Amputation	1(1.1)	2(40.0)	
ICU admission -ve +ve	 75(78.9) 20(21.1)	 4(80.0) 1(20.0)	χ^2=0.003 P=0.955
Length of hospital stay (days) **Median (min-max)**	6(1-23)	5(3-22)	Z=1.80 P=0.072

χ^2=Chi-Square test, Z: Mann Whitney U test, *: Statistically significant

DISCUSSION

As many as twenty percent of all fractures treated in emergency rooms are distal radius fractures. A history of the injury's mechanism, any accompanying injuries, and an appropriate radiological scan are all part of the first evaluation. Options for treatment include dorsal or volar plating with/without arthroscopic support, internal fixation with pins, bridging and non-bridging external fixation, and conservative therapy. However, there are still numerous unknown questions about these fractures, necessitating the need for high-quality prospective randomised trials [6].

This was an observational study conducted on a total of 100 patients with fracture distal radius who were admitted to Emergency Hospital, Faculty of Medicine, Mansoura University within the period from May 2022 to May 2023.

This study aimed to assess the incidence of acute vascular injury associated with fracture distal radius and its impact on short term outcomes.

Regarding the demographic information, according to the current study, the studied cases' ages ranged from 11 to 86 years, with an average of 36.94 ± 16.19. 51% were females, resided in cities, 25 percent were diabetic, 30 percent were hypertensive, and 8% had myocardial infarction. Similar findings have been made by **Refai and his colleagues**[7]**,** who found that women made up 70% of cases while men made up only 30 percent. While **Sultan and his colleagues**[8] have shown that the male/female ratio is 3.1, with 59 male patients (75.6 percent) and 19 female patients (24.4 percent). They concurred with the findings of the present study in that urban people had a higher percentage of distal radial fractures (60 patients, or 77 percent) than rural residents (18 patients, or 23 percent). In addition, they have demonstrated that the age distribution of the 78 patients ranged between 6-45 years with mean age of 17.1 years. This study showed that 35 patients were in the age group of 6-12 years with the highest percentage of 44.9% followed by age group 19-45 years with percentage of 34.6% with 27 patients.

According to the current study, 52% of the cases had the left side affected, compared to 48 percent had the right side. Instead, **Refai and his colleagues**[7] have shown that the right side was the most frequently damaged side in their patients (60 percent) while the left side only accounts for (40 percent) of the total**.**

According to the current study, 90 percent of all fracture types were closed fractures, whereas just 10% were open fractures. The majority of distal radial fractures are closed injuries, meaning the skin above the fracture is uninjured. This is consistent with earlier writers who have demonstrated this [9, 10].

The current study revealed that 40 percent of the analyzed instances involved falling from a height, 26% involved an assault or argument, 21% involved a motor vehicle accident, and 13% involved a fall onto an outstretched hand. Similar to this, **Refai and his coworkers**[7] have shown that falls were the most frequent cause of trauma (76.67 percent), followed by RTA (16.7 percent) and other causes (6.7 percent). The majority of fractures are induced by falling on an outstretched hand with the wrist in dorsiflexion, which may help to explain the mechanism of fracture. The location of the wrist as it hits the ground determines the type and degree of the distal radius fracture as well as any concurrent injuries to the disco-structures of the wrist. The fracture location is influenced by the angle's width. The direction of the force and the compression of the carpus, as well as the various manifestations of ligamentary injuries, are determined by pronation, supination, and abduction [6].

The fracture begins with the radius failing in tension on the volar aspect and moves dorsally where bending forces cause compressive stresses that lead to dorsal comminution. The metaphysis' cancellous impaction further jeopardises dorsal stability. The damage pattern is influenced by additional shearing pressures, which cause articular surface involvement [7]**.**

The current study showed that 52% of the investigated cases had non-skeletal injuries that were related to them in terms of injuries. While, **Refai and his colleagues**[7] have demonstrated that 10% only of their studied cases have associated injuries.

Oren and Wolf[11] have shown that soft-tissue consequences linked to distal radius fractures are frequent in terms of non-skeletal injuries. There have been reports of intercarpal ligament injuries, compartment syndrome, infection, carpal tunnel syndrome, nerve injury, tendinitis, and tendon rupture. Both subsequent to the fracture's treatment and factors inherent to the fracture itself can cause this. An understanding of the consequences can help to enhance treatment plans and prevent long-term disability as therapeutic options for distal radius fractures continue to develop [11].

The current study found that 21% of the examined cases have AO classification class A3 fractures, compared to 17% B1 cases, 16% A2 cases, 15% A1 cases, 9% B2 cases, 8% C1 cases, 7% C2 cases, 4% B3 cases, and 3% C3 cases. Additionally, there was no statistically significant correlation between the AO classification of the examined patients and the occurrence of acute vascular injury related to fracture of the distal radius. AO classification for distal radius fractures divides fractures into three categories based on the involvement of the radiocarpal joint: extra-articular, partial-articular, and complete articular [12].

In their study on distal radial fracture, **Jayakumar and his colleagues**[13] also showed that 27 percent (2,933) of the fractures were classified as type A, 24 percent (2,672) as type B, 47 percent (5,200) as type C, and 2% (235) as unclassifiable. The interobserver agreement was modest for type C fractures (0.44, 95% CI: 0.37-0.52) and significant for type A fractures (0.68, 95% CI: 0.62-74). For type B, it was acceptable (0.28, 95% CI: 0.23-0.35).

According to the results of the current study, there were statistical significance links between the occurrence of acute vascular injury related to distal radius fracture and the following outcomes: impacted hand and hard signs, limb salvage, and amputation. Additionally, of the instances that were analysed, 5 percent and 7 percent of cases, respectively, had hard symptoms and soft indicators. Additionally, **Romagnoli *et al.***[14] evaluated the relationship between hard indications and vascular injury in the extremity and found that 1,108 (58%) of 1,910 individuals showed hard indicators of vascular injury. While operational exploration was largely employed for diagnosis in cases of hard signals, CTA was more frequently used as the diagnostic modality in patients without hard signs. When compared to patients who had exploration for diagnosis (1.5 percent), patients undergoing CTA were more likely to receive (EHR) (10.7 percent).

Numerous authors have written about complications that followed a distal radius fracture. These complications can be divided into two groups: those that are related to the fracture itself (for example, a laceration of the median or ulnar nerve) and those that are the result of surgical or non-surgical treatment [15,16].

The term "vascular complication after DRF" refers to an ulnar artery that is either blocking fracture reduction or that has been shifted dorsally and is now encircling the ulnar styloid [17]. After osteosynthesis of a distal radius fracture with a volar locking plate, isolated radial artery damage is recorded as a pseudoaneurysm [3].

The cases of radial artery lesions as a result of distal radius fractures have been documented in the literature. When the patient had chilly fingers and limited range of motion, **Deepak and his colleagues**[18] first described a case with a radial artery laceration and displaced distal radius and ulna fracture. **de Witte and his colleagues**[5] presented six cases of arterial lesions as a result of distal radius fractures (four radial and two ulnar artery cases), supporting the idea that these vascular complications were discovered when the volar approach was used for osteosynthesis of the fracture. The artery was ligated, and the patient did not appear to have a vascular deficit.

Prior to preoperative treatment planning, assiduous vascular examination should be carried out in all open DRF, even those who seemed to have hematoma of the volar radial surface of the distal forearm, according to a theory put forth by **Kastanis and his colleagues**[2]. Three key goals of reconstruction of damaged arteries in the forearm and wrist are to maintain vascular function, restore hand functionality, and prevent complications due to more vulnerability of limb to future accidents.

On the other hand, there are instances of limb viability in cases where a radial or ulnar artery injury in the forearm is left untreated. While **Perry *et al.*** [19] found that no amputation was carried out in cases of 58 radial and 39 ulnar artery injuries, **DeBakey and Simeone** [20] reported that 5/99 radial and 1/69 ulnar artery lacerations result in amputation of the leg**.** If there is no acute hand ischemia and no significant palmar arch arterial injuries, **Johnson and Johansen**[21] stated that ligating the wounded isolated artery (radial or ulnar) is a safe course of treatment**.** A few difficulties are presented in other research using the radial artery for coronal bypass or radial forearm flaps, which support the previously mentioned choice [22, 23].

For the best results, revascularization time should not exceed 12 hours after the injury, according to **Hunt and Kingsley** [24], who backed the aforementioned choice**.** According to **Kleinert and his colleagues**[25]**,** the ulnar artery was dominant for three or more fingers in 21, 5 percent of cases while the radial artery was dominant for five or more fingers in 57 percent of cases. They also noted that the arterial system in the finger can end differently and can sometimes be seen without an arch.

In contrast to vascular deficiency, **Gelberman and his colleagues**[26] found that the symptoms of cold intolerance appear to be more closely related when brain impairment is present**. de Witte and his coworkers**[5] advised that "it is critical to verify that there is sufficient blood supply to hand from the remainder of the intact artery, before moving to forward ligation, because there could be inadequate arterial supply prior to trauma or anatomic variation".

Prior to surgery, a vascular assessment was conducted, which demonstrated that the affected hands had sufficient artery supply, according to **Kastanis and his colleagues**[2] investigation. In their situation, radial artery ligation was carried out when the tourniquet was released, and it was determined that the hand's perfusion was adequate. At the last checkup, none of the patients had any signs of previous vascular damage.

In comparison to the lower extremities, limb salvage is pursued more vigorously in the upper extremities. Even if the patient has a mangled extremity (i.e., damage to three of the four functional elements [nerves, vessels, bones, soft tissues]), limb salvage can usually be attempted; however, on rare occasions, the injury to the extremity is so severe that primary amputation is necessary to save the patient's life. In some patients with multisystem injuries, extended treatments for attempted limb salvage may be prohibited by the severity of concomitant injuries. Despite its many risk factors, injury to the wrist's proximal portions is typically a sign that limb salvage is necessary [27].

CONCLUSION

The results of the current study showed that the mean age was 36, the male to female frequency was similar, and the most frequent cause of injuries was falling from a height. The most prevalent accompanying characteristics were skeletal injuries. In addition, 21% of the examined cases fall into the AO classification class A3, 17% B1 cases, 16% A2 cases, 15% A1 cases, 9% B2 cases, 8% C1 cases, 7% C2 cases, 4% B3 cases, and 3% C3 cases. Furthermore, there was a strong correlation between the presence of acute vascular damage and distal radius fracture.

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