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Radiologıcal Evaluation of Volar Cortical Angle in the Anatolian Population

Evaluación Radiológica del Ángulo Cortical Volar en la Población Anatoliana

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SUMMARY: Distal radius fractures are the most common fractures of the upper limb. The most commonly used method in the repair of these fractures is volar locking plates. Recently, the frequency of removal of volar locking plates after surgery has increased. There are many factors in its reduction. Anatomically, incompatibility of the distal end of the radius with volar locking plates is one of them. In previous studies, different volar cortical angle (VCA) values were found in other races. For this reason, this study aimed to determine the mean values by making VCA measurements of the Anatolian population. The study was designed retrospectively. In the study, measurements were made on computed tomography (CT) images of the distal end of the radius of 53 men and 28 women. Radial width, intermediate volar angle, and radial volar angle were measured in the images. On average, the radius width was 23.35±1.96 mm, and the intermediate volar angle was 26.02±.3.83°, radial volar angle was 24±3.07°. Radial width, intermediate volar angle, and radial volar angle differed significantly by gender ($p<0.001$). A significant correlation was found between radius width, intermediate volar angle, and radial volar angle values ($p<0.001$). It has been determined that the Anatolian population has a different VCA value than the European, Asian, and other populations. When using volar locking plates in distal radius fracture surgery, volar locking plates should be selected by considering the average values of the races.

KEY WORDS: Radius; Volar cortical angle; Wrist; Distal end radius; Volar plocking plate.

INTRODUCTION

Distal radius fractures, which constitute 44 % of all forearm and hand fractures, are the most common type of upper limb fractures. One out of six patients presenting to the emergency department with a bone fracture has a distal radius fracture (Dündar *et al*., 2022; Abdel-Wahed *et al*., 2022). However, despite the high incidence of distal radius fractures, there is still no consensus on the optimal treatment strategy. Current treatment options include closed reduction, closed reduction with percutaneous needling, intramedullary fixation, external fixation, and various open reduction and internal fixation strategies (Alter & Ilyas, 2018). The standard treatment for distal radius fracture is volar locking plate fixation, which restores anatomy, joint alignment, and stability. Volar-locking plate fixation provides good clinical outcomes for most distal radius fractures (Nanno *et al*., 2020). It allows for early rehabilitation and early return to activities of daily living. Open reduction internal fixation (ORIF) with a volar plate is a common surgical approach, although there are variations. Volar plating is a stable fixation method, but there are significant differences between surgeons and surgeons regarding postoperative immobilization (Sørensen *et al*., 2020).

Most current volar plate designs feature the volar cortical angle (VCA), i.e., an angle of 25° across the entire width of the plate between the volar lip and the distal radius shaft. The knowledge that the VCA value of this grade is anatomically correct is controversial. Bassi *et al*. (2003) reviewed lateral wrist radiographs and found the mean VCA to be 37°. However, as this study was based only on straight lateral radiographs, it was impossible to assess whether there was any variation within the VCA across the width of the distal radius. Given that most volar plate designs have the same volar angle across their width, any variation in the VCA

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within the same distal radius may hinder correct anatomical fixation. This has been confirmed in anatomical studies showing that the geometry of the volar surface of the distal radius is highly complex (McCann *et al*., 2010, 2012). It is well established that accurate reconstruction of the distal radial anatomy is required to achieve good functional outcomes following ORIF (Evans *et al*., 2014).

If the VCA of current volar plate designs does not reflect the normal anatomy of the distal radius, anatomical reconstruction may be precluded. Volar plates available in the market were made according to the values of the western population. Therefore, this study aims to evaluate the VCA angle in the Anatolian population according to sex and to find the mean VCA values in the Anatolian population.

MATERIAL AND METHOD

This retrospective study was conducted in a tertiary hospital between January 2021 and November 2021. Measurements were made on Computed Tomography (CT) of individuals with no fracture or mass in the wrist at the Training and Research Hospital. Radial width, intermediate volar angle, radial volar angle measurement data, and demographic data, including age and sex, were collected for each patient. Measurements were made using the Radiant DICOM Viewer program. To preserve authenticity, all morphometric measurements were made by a single independent staff member. Each parameter was measured thrice, and the average value taken was used to reduce the within-observer error.

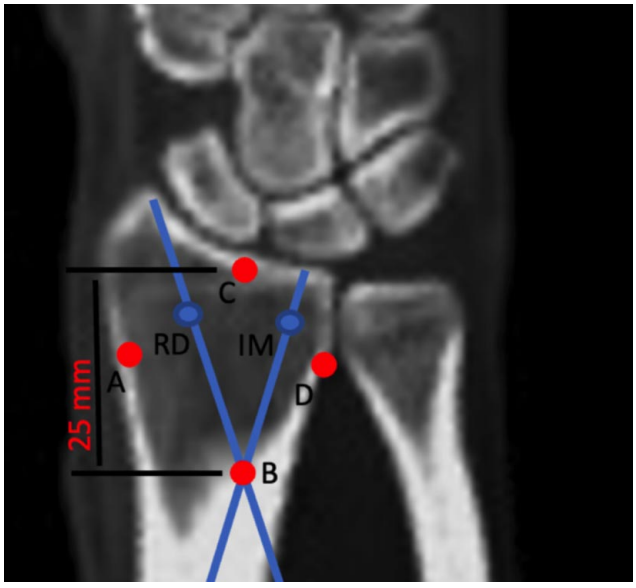

Fig. 1. Points determined for VCA measurement. A: Radial corner of the margin fed by the arteries. B: Point located 25 mm proximal to the C point. C: Volar radial corner point of the area where it articulates with the os lunatum distal to the radius. D: Ulnar corner of the margin fed by the arteries. RD: Midpoint between points A and C. IM: Midpoint between points C and D.

Data were analyzed using SPSS statistical software version 21 for Windows. A comparison of means was made using Mann-Whitney U Test and Pearson Correlation Test, and significance was set at $p<0.05$.

Among the evaluated parameters are the points where the volar cortical angle was measured (Fig. 1) and the points where the radial volar cortical angle and intermediate volar cortical angle was measured (Figs. 2 and 3).

The study protocol was reviewed a and approved by the Ethics Committee which certified that the present study was performed in accordance with all required guidelines and regulations. The dataset did not contain any personally identifiable information, and The Hospital waived the need for informed consent allowing an opt-out approach for the secondary use of existing data.

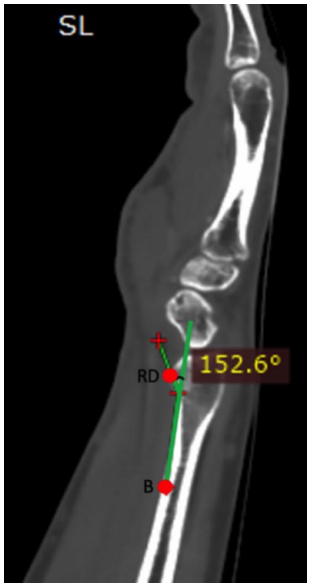

Fig. 2. Radial volar cortical angle measurement. RVA: Angle between the line drawn from RD and the line drawn from point B.

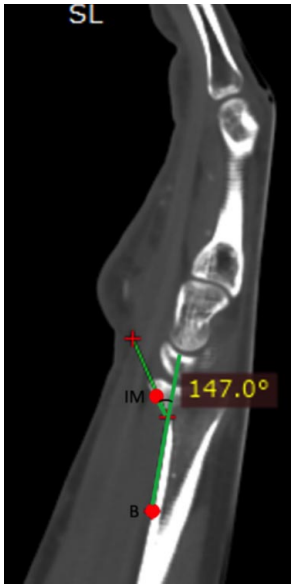

Fig. 3. Intermediate volar cortical angle measurement. VCA: Angle between the line drawn from IM and the line drawn from point B.

RESULTS

Eighty-one (n = 81) CTs were included in this study for analysis. The number of men was 53, and the number of women was 28. The ages of the patients ranged from 17 to 88, with a mean age of 48.37±20.08 standard deviation (SD).

When the data of the study were evaluated in general, the radius width was 23.35±1.96 mm, the intermediate volar angle was 26.02±.3.83°, and the radial volar angle was 24±3.07° (Table I). When the data were compared according to the sexes, the radius width was 27.19±0.24 mm in women and 31.6±0.18 mm in men. The intermediate volar angle was 23.54±3.25° in women and 27.33±3.46° in men. Radial volar angle values were 21.96±3.40° in women and 25.08±2.26° in men. Radial width, intermediate volar angle, and radial volar angle differed significantly by sex ($p<0.001$) (Table II).

A significant correlation was found between radius width, intermediate volar angle, and radial volar angle values ($p<0.001$) (Table III).

Table I. Radius width, Intermediate Volar Angle and Radial Volar Angle mean values.

	Mean	Std. Deviation	N
Radius Width (mm)	30.08	.29710	81
Intermediate Volar Angle (°)	26.02	3.83005	81
Radial Volar Angle (°)	24.00	3.07817	81

Table II. Radius width. ıntermediate volar angle and radial volar angle mean sex values.

	Women	Men	P<
Radius Width (mm)	27.19±0.24	31.6±0.18	0.00
Intermediate Volar Angle (°)	23.54±3.25	27.33±3.46	0.00
Radial Volar Angle (°)	21.96±3.40	25.08±2.26	0.00

DISCUSSION

Restoration closest to the wrist anatomy, good joint stabilization, pain control, and early progressive joint mobilization to prevent contracture are the main factors in the treatment of fracture surgery (Freeland & Luber, 2005). Fixed-angle distal radius volar locking plates are systems with locking screws that are anatomically angled to fit the palmar surface and hold the subchondral region at a fixed angle (Agir *et al*., 2014). These features facilitate reduction, and fixation becomes more stable. While volar plates were initially used to manage fractures in osteoporotic bone and repair comminuted fractures, and joint fractures, they later became the most commonly used implant for the internal fixation of distal radius fractures (Alter & Ilyas, 2018).

These prefixed plates are said to facilitate the reduction of the fractured distal radius. However, this reduction will not be an actual anatomical reduction because fractured distal radius fragments that fit the plate will accompany the volar angle of the plate and not the original volar angle (Downing & Karantana, 2008; Nalbant *et al*., 2023). The disadvantages of this technique are the difficulty of placing fixed-angle screw sockets on these plates during surgery, the risk of screws going into the joint, and the inability to place pre-shaped fixed-angle plates on the volar surface of the distal Radius (Agir *et al*., 2014). There are quite several fixed-angle locking volar plate designs available. These volar plates are biomechanically stronger than their traditional volar and dorsal counterparts and are fixed-angle plates that allow early movement. They can reduce the amount of early loss of motion, as seen with some other fixation methods (Freeland & Luber, 2005). Another inefficiency of fixed-angle locked volar plates is seen in fractures including the volar lip. The volar concavity terminates distally at the volar lip of the distal radius, where the flexor tendons slide close to the bone and are subject to abrasion by necessary hardware. Hardware placed at or beyond this point can cause flexor tendon irritation and subsequent rupture. This point is also called the watershed line (Agir *et al*., 2014).

Although volar locking plates have been shown to produce satisfactory results, they sometimes need to be removed. To date, there are only a few published studies of plaque removal following surgical treatment of DRF. A previous study reported that causes of plaque removal were pain (30

Table III. Radius width. ıntermediate volar angle and radial volar angle correlations.

		Radius Width	Intermediate Volar Angle(°)	Radial Volar Angle (°)
Radius Width	Pearson Correlation	1	.511**	.577**
	Sig. (2-tailed)		.000	.000
	N	81	81	81
Intermediate Volar Angle(°)	Pearson Correlation	.511**	1	.893**
	Sig. (2-tailed)	.000		.000
	N	81	81	81
Radial Volar Angle(°)	Pearson Correlation	.577**	.893**	1
	Sig. (2-tailed)	.000	.000	
	N	81	81	81

**. Correlation is significant at the 0.01 level (2-tailed).

Table IV. Radius width, Intermediate Volar Angle, and Radius Volar Angle's other research values comparison.

	Nalbant *et. al*. (2023)	Bassi *et. al*. (2003)	Agır *et. al*. (2014)	Evans *et. al*. (2014)	Kwak *et. al.* (2016)
Volar Cortical Angle	23.5°	37.1°	37.7°	32.9°	28.5°
Intermediate Volar Angle	26°	-	-	34.1°	30°
Radial Volar Angle	24°	-	-	31°	21°

%), tenosynovitis (27 %), malunion (24 %), infection (12 %), nonunion (6 %), and tendon rupture (3 %).

Because the positioning of the plate is closely related to the volar surface anatomy of the distal radius, the VCAs of the volar radius should be important anatomical parameters for proper plate placement. Bassi *et al*. (2003), measured the VCA of 50 normal lateral wrist radiographs and reached a mean VCA of 37.1°. Kwak *et al*. (2017), stated in their study that VCA was around 28.5° on average. Evans *et al*. (2014) measured the VCA of 100 distal radiuses using computed tomography scans and found the mean VCA to be 32.9°. In this study, the mean VCA was found to be 24°. As in other studies, the VCA in men was significantly higher than women.

Kwak *et al*. (2016), reported intermediate VCA as 30° and Evans *et al*. (2014), found an intermediate VCA of 34.1° in their study, while an intermediate VCA was found 26° in this study. Kwak *et al.* (2016), found the radial VCA to be 21° in their research, while Evans *et al*. (2014), found the radial VCA to be 31°. Also, Kwak *et al.* (2016), stated in their study that there was no correlation between radius width and VCAs. In this study, the radial VCA was found to be 24°, and a significant correlation was found between radius width and VCAs. It is mathematically expected that the VCAs will change when the radius width changes. This confirms the validity of our measurements. When the results are evaluated, differences in VCAs are observed between races (Table IV). In addition, intermediate VCA was significantly greater than radial VCA in all studies. Similar to the results of this study, Oura *et al*. (2015), reported that the volar surface of the distal radius is concave in the axial plane, supinated from proximal to distal, and the volar intermediate column is more prominent than the radial column.

One limitation of this study was the small number of samples. In measurements made with more samples, more realistic data can be reached. However, in this sample, too, it has been determined that VCA varies in the Anatolian population.

Today, the plaque removal rate varies between 10 % and 12 % annually (Palola *et al*., 2021). It has been reported in previous studies that VCA between volar locking plates may be effective in the occurrence of these complications since it varies among individuals (Foo *et al*., 2013; Agir *et al*., 2014; Kwak *et al*., 2017; Alter & Ilyas, 2018).

CONCLUSION

It has been determined that the Anatolian population has a different VCA value than the European, Asian, and other populations. According to research, VCA varies according to race. Racial differences should be considered for volar locking plates to achieve complete mechanical success. By measuring the volar angles of the contralateral distal radius before the operation and adjusting the plate to the right volar angle, an actual anatomical reduction can be obtained without losing time in the operation.

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RESUMEN: Las fracturas del radio distal son las fracturas más comunes del miembro superior. El método más utilizado en la reparación de estas fracturas son las placas de bloqueo volar. Recientemente, ha aumentado la frecuencia de extracción de placas de bloqueo volar después de la cirugía. Existen muchos factores en su reducción y anatómicamente, la incompatibilidad de la extremidad distal del radio con las placas de bloqueo volar es una de ellas. En estudios anteriores, se encontraron diferentes valores del ángulo cortical volar (VCA) en otras grupos. Por esta razón, este estudio tuvo como objetivo determinar los valores medios, realizando mediciones de VCA de la población de Anatolia. El estudio fue diseñado de manera retrospectiva. En el estudio, se realizaron mediciones en imágenes de tomografía computarizada (TC) de la extremidad distal del radio de 53 hombres y 28 mujeres. En las imágenes se midieron el ancho radial, el ángulo volar intermedio y el ángulo volar radial. En promedio, el ancho del radio fue de 23,35 ± 1,96 mm, el ángulo volar intermedio fue de 26,02 ± 3,83° y el ángulo volar radial fue de 24 ± 3,07°. El ancho radial, el ángulo volar intermedio y el ángulo volar radial difirieron significativamente según el sexo ($p<0,001$). Se encontró una correlación significativa entre los valores del ancho del radio, el ángulo volar intermedio y el ángulo volar radial ($p<0,001$). Se ha determinado que la población de Anatolia tiene un valor de VCA diferente al de las poblaciones europeas, asiáticas y otras. Cuando se utilizan placas de bloqueo volar en cirugía de fractura de la extremidad distal del radio, las placas deben seleccionarse considerando los valores promedio de los individuos de diferentes grupos.

PALABRAS CLAVE: Radio; Ángulo cortical volar; Muñeca; Extremidad distal del radio; Placa de bloqueo volar.

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