

# Analysis of Wrist Morphology Through Hamate and Lunate Bone Variations in Anatolian Population Using Plain Radiography

**Análisis de la Morfología de la Articulación Radiocarpiana a Través de las Variaciones de los Huesos Hamato y Semilunar en la Población de Anatolia Mediante Radiografía Simple**

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**SUMMARY:** The present study aimed to evaluate wrist (lunate) anatomy in terms of the incidence of lunatum morphology on plain-radiographs among the Anatolian (Turkey) population, accompanied by demographic analysis. We obtained all the patients' data regarding demographical features, diagnosis, and posteroanterior (PA) X-ray imaging. Two radiograph-reviewers repeated the analysis twice, one month later, blinded to their findings before the previous review. The lunatum structure was determined as Type-1 (n:293) and Type-2 (n:207) for each radiograph. Most of the 500 wrists' radiographs [n:293 (58.6 %)] were type-I lunate. The mean age was 36.7±13.3 (range:18-90) years. Sex distribution was as follows: 185 (63.1 %) males to 108 (36.9 %) females. Type-2 lunate was seen in 207 participants (41.4 %). The mean age for type-2 was 41.6±15.2 (18-88) years. 142 (68.6 %) participants were male sex, while 65 (31.4 %) were females. The mean age of subjects with type-I showed a difference with type-II (p=0.007). There was no relationship in terms of sex (p=0.206) between the groups. In the Anatolian region, type-1 lunate was dominant compared to type-2. The incidence rate of lunate type in Anatolian population was similar to the Arab population.

**KEY WORDS:** Wrist morphology; Hamate; Lunate; Variation; Plain radiography.

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## INTRODUCTION

The lunate, considered the critical point of the wrist, integrates the wrist, and its distal surfaces articulate with os hamatum during the adduction move (Balci *et al.*, 2023). Localized in the middle of scaphoid-triquetrum bones, this bone structure has a smooth-surface at proximal side that connects with the crescent-shaped Lower radio-ulnar articular disc (Yakkanti *et al.*, 2020). Loads originating from the carpal bone and ligament accumulate on this structure, and the clinical implications of morphological variances are still the subject of research (Cohen *et al.*, 2023).

Different intercontinental reports are published for anatomical variants of this bone, of which new varieties are detected daily by surgeons (Boesch *et al.*, 2020; Thayer *et al.*, 2022). In some presented cases, the triquetra-hamatum is located on a flat inclined the capito-lunatum. However, in some individuals, the triquetrohamate-joint is separated from the capitulunate by a concave-facet (Park *et al.*, 2019; Rachunek *et al.*, 2022). Two main types are defined

according to the presence of a facet articulating distally with the hamatum bone (Hein *et al.*, 2022). Type-I lunate means that there is no facet articulation with the hamatum. On the contrary, if there is no medial facet articulating, it is accepted as Type II (Leonardo-Diaz *et al.*, 2020). This variation is clinically essential to physicians for surgical approaches. Osteoarthritis is more common in type-II lunate (Rhee *et al.*, 2009). Similarly, proximal cartilage erosion of the hamate is mainly encountered in type II (Ruoff *et al.*, 2016). The study of Nakamura *et al.* (2001) suggested that mechanical locomotion differences between these types may be a factor in leading to lunohamatum arthrosis, while type-I exhibits different movement from type-II during ulnar-radial deviation (Chinen *et al.*, 2022; Rachunek *et al.*, 2022).

Adaptation to the intercarpal ligaments may affect carpal kinematics. Hence, biomechanical analyses were conducted with radiographic imaging obtained from the cadaver study, and variations in lunate morphology were

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revealed to facilitate clinical use (Riederer *et al.*, 2021; Mania *et al.*, 2022). Analyzing regional and populational differences with radiographic imaging will protect physicians from unforeseen clinical and surgical surprises (Dharap *et al.*, 2006a). The actual literature indicates that European, Asian, and Arabian populations have the most studies for incidence of type-I and type-II (Dharap *et al.*, 2006; Madani *et al.*, 2022; Balci *et al.*, 2023). There is no report for the Anatolian population represented by Turkey, which combines the geography of Europe and Asia. The present study aimed to evaluate wrist anatomy in terms of the incidence of lunatum morphology on plain-radiographs among the Anatolian (Turkey) population, accompanied by demographic analysis.

## MATERIAL AND METHOD

**Study Design.** All the patients over 18 years with radiographs of the wrist record from the dates of Jan 2022 to Jan 2023 enrolled in the present research and reviewed retrospectively. Because it has a retrospective design according to the relevant regulations, the study is exempt from the approval requirement from a Review Board or equivalent Ethics Committee. The study obtained all the patients' data regarding demographical features, diagnosis, and posteroanterior (PA) X-ray imaging. According to the inclusion/exclusion criteria of the study, 681 radiographs enrolled in the review. Of these patients, 500 PA wrist radiographs were available.

**Radiography.** The radiographs were mainly selected from patients with pain or trauma over the wrist, while a few radiographs were requested for age confirmation. Two radiograph-reviewers repeated the analysis twice one month later, blinded to their findings before the previous review. The lunatum structure was determined as Type-1 (n:293) and Type-2 (n:207) for each radiograph (Fig. 1). Inclusion criteria were having a clean plain X-ray graph with PA, forearm in

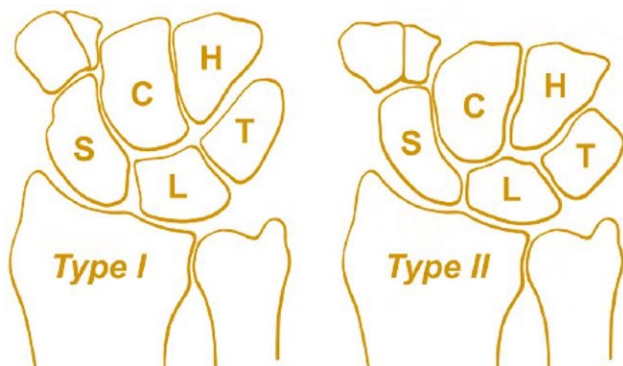


Fig. 1. Identification of type-1 and type-2 in flat illustration

neutral rotation, 90 degrees of elbow flexion, and neutral wrist flexion. Patients with carpal fractures, dislocations, or artifacts on their radiographs were excluded from the present study. Other criteria for exclusion were having a history of previous surgery, being under 18 years, and having any fracture or congenital deformity.

**Statistical Analysis.** The statistical package program (SPSSv25 for Microsoft Windows, USA) analyzed all results. The cross-tabulation determined the lunate percentages of type I/II concerning sex. The independent sample t-test analyzed the age in groups while the Pearson-Chi-square assessed the effect of sex. To determine the accuracy of the two radiograph-readers, we performed a reproducibility analysis. The Cohen-kappa's coefficient compared the radiograph-readers for their first and second assessments. For the reliability analysis of readers, Fleiss kappa coefficient with the observations made by each observer during the initial assessment. Fleiss kappa was 0.483, and Cohen kappa was 0.533 for radiograph-readers, which means moderate results. The p-value of <0.05 was considered significant.

## RESULTS

Most of the 500 wrists' radiographs [n:293 (58.6 %)] were type-I lunate, as seen in Figure 2. For the type-I group, the mean age was  $36.7 \pm 13.3$  (range:18-90) years. Sex



Fig. 2. Type-1: posteroanterior radiograph of the wrist (L: lunate, C: Capitate, H: hamate, and T: triquetrum).

distribution was as follows: 185 (63.1 %) males to 108 (36.9 %) females. Type-2 lunate was seen in 207 participants (41.4 %), as seen in one radiograph in Figure 3. The mean age for type-2 was  $41.6 \pm 15.2$  (18-88) years. 142 (68.6 %) participants were male sex, while 65 (31.4 %) were females. As shared in Table I, the mean age of subjects with type-I showed a significant difference with type-II lunatum ( $p=0.007$ ). There was no relationship in terms of sex ( $p=0.206$ ) between the groups.

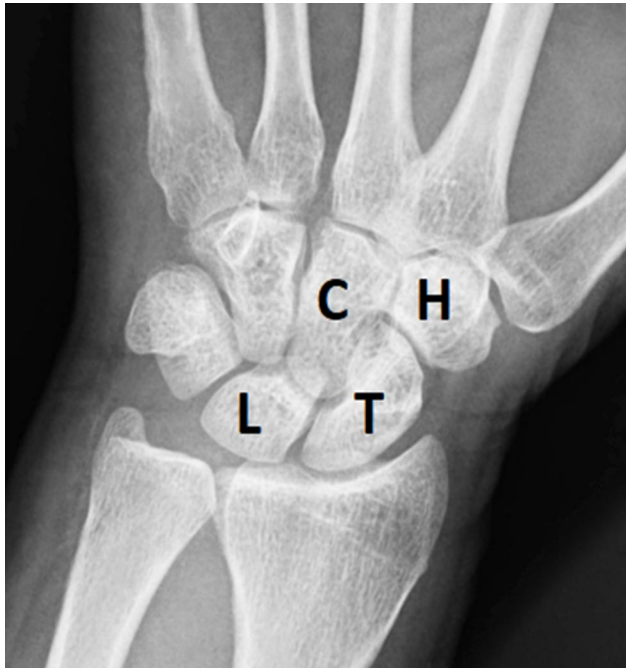


Fig. 3. Type-2: posteroanterior radiograph of the wrist (L: lunate, C: Capitate, H: hamate, and T: triquetrum).

## DISCUSSION

The present study is a novel analysis of its results and is the first analysis carried out in Anatolian geography. It evaluates the wrist radiography with the highest attendance among the similar studies we have scanned in the literature. Compared to the world, in Anatolian geography, type-1 lunate is more common than type 2 in Europe, America, and Asia, and however, it is only similar to the variance in the Arab population.

The clinical importance of different lunate types, prone to many variations described in the literature, has recently been emphasized (Nakamura *et al.*, 2001). In the light of studies, wrist variations due to individual structural differences may be associated with different levels of sensitivity to some specific surgical processes (Leonardo-Diaz *et al.*, 2020; Hein *et al.*, 2022). The articulation structure in this region may have a clinical effect by altering the high conduction on the radiocarpal joint (Rhee & Moran, 2020). Type-II lunate may prevent fragmentation of the lunate fracture, and the medial-surface of the lunatum is separated from its distal surfaces (Cerezal *et al.*, 2002). In this sense, when we consider regional differences, typing in this joint will be beneficial not only in terms of morphology, but also for the surgical and clinical aspect.

The lunate incidence varies in different populations, and these variations are also related to the number of participants and the methodology of our study (Goeminne *et al.*, 2022; Thayer *et al.*, 2022). For example, the incidence of type-II differed in two different regions of France and was reported as 57 % (Dautel & Merle, 1997) and 55 % (Aufauvre *et al.*, 1999). In America, the incidence of type-II in the Texas population was 74 %, while the California population reported only a 51 % incidence for type II lunate (Viegas *et al.*, 1993). Although the breadth of the American continent has an impact on that issue, this difference may be due to the multiethnic composition of the population in North-side (Pfirmsmann *et al.*, 2002). Among Asians, it was highest in Japanese, with a rate of 57.5 %. Malaysia indicates the lowest incidence of type-II 26.8 % (Dharap *et al.*, 2006b). They were somewhat in the middle of those seen in Malays, Japanese and French and had a much lower incidence than in America. The incidence of type II lunate was reported as 38.8 % in the Arab population, which is the closest place to the Anatolian geography (Dharap *et al.*, 2006a). According to the present study, the type-2 incidence was 41.4 % in the Anatolian population, where Turkey is located. This incidence rate is closest to the Arab population, which also indicates that geographic proximity plays an important role in this situation. There was no difference in terms of sex in comparison to lunate morphology. However, type-1 lunates had a younger age than type-2 lunate in terms of age.

Table I. Demographic data of participants according to Lunate morphology.

Variables	Type-1 (n:293)	Type-2 (n:207)	P value
Age, year	$36.7 \pm 13.3$ (18-90)	$41.6 \pm 15.2$ (18-88)	0.007
Sex, m/f	185 (63.1%) / 108 (36.9%)	142 (68.6%) / 65 (31.4%)	0.206

\* Age was analyzed by the independent t-test and given as mean  $\pm$  standard deviation. \*\* Sex was analyzed by the Chi-Square test and given as n (percent).

In wrist radiography in morphological studies, size of the study and the geographic variations in the medial-facet of the lunatum can be misinterpreted among radiologists. They may have difficulty interpreting a minor medial facet that overlaps the ulnar edge of the lunate bone, especially for capitate articulation. When the lunate occupies less anteroposterior-width, distinguishing the presence of a medial-facet on the radiographic articular-line cannot be clear. The Type-II incidence varies in different world populations and need to be analyzed carefully by radiograph-readers. To prevent this error from affecting the study results, we performed consistency and accuracy analysis with image analysts. In our study, Fleiss kappa value for inter-observer agreement and Cohen kappa for the radiographic analysis's reproducibility were mild.

The most substantial aspect of the present study is that we analyzed lunate variations in the Anatolian geography for the first time and with many subjects. The study had partial limitations; most importantly, we used plain radiographs to evaluate lunate morphology, which was also used in previous studies and was lacking in its adequacy. However, to reduce the BIAS that may result from their interpretation of our radiographic results, we applied interpreters-specific reliability measures such as Cohen & Fleiss kappa coefficient.

As a conclusion, in the Anatolian region, type-1 lunate was dominant compared to type-2, and it was seen as one of the societies with the highest percentage in the world. This incidence rate was only similar to the variance in the Arab population, our geographical neighbor. There was no difference in terms of sex in comparison to lunate morphology. However, type-1 lunates had a younger age than type-2 lunate in terms of age. Since Anatolian geography has a large area, reaching more vital data with broad participation analyses will be possible.

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**RESUMEN:** El presente estudio tuvo como objetivo evaluar la anatomía de la articulación radiocarpiana en términos de la incidencia de la morfología del hueso semilunar en radiografías simples entre la población de Anatolia (Turquía), acompañado de un análisis demográfico. Obtuvimos todos los datos de los pacientes con respecto a las características demográficas, el diagnóstico y las imágenes de rayos X posteroanteriores (PA). Dos revisores de radiografías repitieron el análisis dos veces, un mes después, sin conocer sus hallazgos antes de la revisión anterior. La estructura del lunatum se determinó como Tipo-1 (n:293) y Tipo-2 (n:207)

para cada radiografía. La mayoría de las 500 radiografías de muñecas [n:293 (58,6 %)] fueron semilunar tipo I. La edad media fue de  $36,7 \pm 13,3$  (rango: 18-90) años. La distribución por sexos fue la siguiente: 185 (63,1 %) hombres y 108 (36,9 %) mujeres. El semilunar tipo 2 se observó en 207 participantes (41,4 %). La edad media para el tipo 2 fue de  $41,6 \pm 15,2$  (18-88) años. 142 (68,6 %) participantes eran del sexo masculino, mientras que 65 (31,4 %) eran del sexo femenino. La edad media de los sujetos con tipo I mostró una diferencia con el tipo II ( $p = 0,007$ ). No hubo relación en cuanto al sexo ( $p=0,206$ ) entre los grupos. En la región de Anatolia, el semilunar tipo 1 era dominante en comparación con el tipo 2. La tasa de incidencia del tipo semilunar en la población de Anatolia fue similar a la de la población árabe.

**PALABRAS CLAVE:** Morfología de la articulación radiocarpiana; Hamato; Lunado; Variación; Radiografía simple.

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