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Research article

Six new examples of the bipartite trapezoid bone: Morphology, significant population variation, and an examination of pre-existing criteria to identify bipartition of individual carpal bones

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ABSTRACT

Carpal bone bipartition is a developmental variant resulting in the division of a normally singular carpal into two distinct segments. Cases involving the scaphoid are best known, though many other carpals can be affected, including the trapezoid. Six new examples of bipartite trapezoids, identified in African and Asian anatomical and archeological samples, are reported here and compared with the eight previously known. While the site of bipartition is consistent, the resulting segments exhibit variability in their articulations with neighboring carpals. Five of the six affected trapezoids were identified in African or African-derived samples, yielding a significantly higher frequency (0.323%) of bipartite trapezoid than seen in anatomical or archeological series of European origin. Bilateral bipartite trapezoids in archeological remains from the Mid Holocene site of Gobero (Niger) are potentially the oldest bipartite carpals yet identified in humans. Their discovery may indicate that trapezoid bipartition is a condition that has been present in African populations since prehistoric times, though more data are needed. Because bipartite carpals may be symptomatic and can occur as part of syndromes, the significant population variation in frequency identified here has potential utility in both anatomical and clinical contexts. However, a comparison of the morphological appearance of bipartite trapezoids with the suggested criteria for bipartite scaphoid diagnosis indicates that these criteria are not equally applicable to other carpals. Fortunately, due to the rarity of fracture, identification of the bipartite trapezoid and separating it from pathological conditions is considerably easier than diagnosing a bipartite scaphoid.

1. Introduction

Carpal bone bipartition is a developmental variant resulting from the formation of two mesenchymal or cartilaginous carpal centers instead of one, or from the non-union of two ossification centers within a single carpal bony template (Gruber, 1879; O'Rahilly, 1953). Bipartite carpal bones may be symptomatic (Richards et al., 1987; Kim et al., 2005; Et-tai et al., 2008), misdiagnosed as an ununited fracture (Dwight, 1907), and occur as part of malformation syndromes (Tate et al., 2000; Saccomanni, 2009; Unruh and Shin, 2011) or endocrinopathies including cretinism (O'Rahilly, 1953). Most published cases of bipartite carpal bones involve the scaphoid, though the trapezium, trapezoid, triquetral, and lunate may each also be represented by two independent bony elements (e.g., Thilenius, 1894, in Windle, 1895; O'Rahilly, 1953; Loh et al., 2011; Barnes, 2012). Bipartition of the trapezoid has been particularly infrequently reported, with seven cases published since the first in 1879 (Table 1), and only two cases described since 1887. As a result of the sparse and dated literature on its occurrence, little is known about this anatomical variation. The purpose of this report is to: (1) describe five new cases, including the earliest known archeological case, occurring bilaterally in a mid Holocene burial from the Saharan site of Gobero (Niger), (2) describe the morphological characteristics of the bipartite trapezoid, (3) demonstrate statistically significant population variation in the occurrence of this carpal variant, and (4) discuss issues with the differential diagnosis of carpal bipartition. These new findings are important for the proper interpretation and identification of bipartite carpals in both anatomical and clinical contexts.

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Table 1
All known cases of bipartite trapezoid.

Origin	Sex	Age	Side, laterality	Source
European[a]	Male	Adult?	L, laterality?	Gruber (1879)
European[a]	?	?	?	Flesch (1879)
Algerian	Male	70 years	Bilateral	Vincent (1881)
European[a]	Male	Adult	R, laterality?	Turner (1883)
European[a]	Male	Adult?	R, laterality?	Gruber (1887)
European[a]	?	?	?	Prescher (2001)
Greece[b]	Female	Adult	L, unilateral	Barnes (2012)
South African[c] (A1991)	Female	34 years	R unilateral	This study
South African[c] (A2510)	Male	40 years	R unilateral	This study
South African[d] (A4035)	Female	22 years	L unilateral	This study
Niger[e]	Male	20–30 years	Bilateral	This study
Thailand	Male	49 years	L unilateral	This study

[a] Unspecified but likely European.
[b] Archeological case from Frankish Corinth.
[c] Recorded as Zulu in collection records.
[d] Unknown tribal affiliation.
[e] Archeological case from Mid Holocene Sahara.

2. Background

2.1. Prior cases

Seven cases of bipartite trapezoid have hitherto been published (Table 1). The Russian anatomist Wenzel Gruber reported the first case in the left hand of a male specimen in 1879 (Gruber, 1879), followed by two cases originally misidentified as examples of the accessory bone *os centrale* (Flesch, 1879; Vincent, 1881; Gruber, 1883, in Gruber, 1887), one of which occurred in Algeria (Vincent, 1881). Additional cases were identified in the late 19th century by Turner (1883) and Gruber (1887). More recently, Prescher (2001) identified a case during dissection, though it is incompletely described. A 13th century case of bipartite trapezoid recovered from archeological excavations at Frankish Corinth (Greece) has also been depicted in an atlas of congenital variation of the skeleton (Barnes, 2012). The unilateral case affects the left side, but unfortunately, it is not described in adequate detail.

2.2. Morphology

Bipartition of the trapezoid occurs through the angle of the bone, resulting in a larger, flattish, oval portion dorsally, and a smaller cubical palmar portion (Fig. 1). Early anatomical reports noted variation in the articulations of each trapezoid segment with the adjacent carpals (Table 2). The dorsal portion articulates with the scaphoid, trapezium, and second metacarpal base in all prior described cases, and on occasion also with the capitate and third metacarpal base. The palmar trapezoid portion articulated with the capitate, trapezium, and second metacarpal base in each case, but inconsistently with the scaphoid. The nature of the interface between the two trapezoid segments has been less consistently noted, with Gruber characterizing it as a facet indicative of a synchondrosis in the earliest published specimen (Gruber, 1879). In a later case, the interface between the two segments consists partially of a facet, with the adjacent area roughened due to ligamentous attachment (Gruber, 1887).

2.3. Sample frequencies

As a result of the low number of cases adequately published, few sample frequencies based on large samples are known. Anatomical dissections by Gruber revealed the first case in a series of 1800 hands (Gruber, 1879), and his later case in an additional sample of 3700 hands (Gruber, 1887). Overall, the frequency of bipartite trapezoid in Gruber's samples is 0.036% (2/5500). The German anatomist Pfitzner did not identify any bipartite trapezoids in his analysis of 1456 hands (Pfitzner, 1895, 1900). These samples are likely to be primarily composed of individuals of European ancestry. As a result, little is known about potential frequency variation between populations.

3. Materials and methods

Ossification of the trapezoid bone commences at 4–5 years of age and by 10 years it is readily identifiable with characteristic morphology (Scheuer and Black, 2000). The trapezoid continues to increase in size until achieving its adult proportions between 12.5 and 15 years of age (Scheuer and Black, 2000). Although the recognizable characteristics of the trapezoid are apparent earlier, data for this study were only collected on individuals of at least 13 years of age. All trapezoid bones studied were ossified and bearing the typical angular morphology of the skeletally mature trapezoid.

The bipartite trapezoid bone examples reported here were incidental discoveries identified by the first author between 2003 and 2013 in four skeletal series composed of individuals of African or Asian ancestry. In total, 1803 trapezoids from 950 individuals were examined from the four samples.

Data from the larger of the two African anatomical samples was collected during research on congenital skeletal variation in the Raymond Dart Collection of Human Skeletons at the University of Witwatersrand (Johannesburg, South Africa) (Burnett, 2005), a documented skeletal series derived primarily from anatomical dissections of 20th century white and indigenous South African populations (Dayal et al., 2009). Combined with a prior pilot study conducted by the first author, the Dart Collection sample includes analysis of 530 indigenous South Africans (237 females, 13–90 years of age; 293 males, 15–90 years of age) represented by 986 trapezoids. Skeletal analysis also included 602 trapezoids from 304 African-Americans (145 females, 17–80 years of age; 159 males, 19–77 years of age) in the Robert J. Terry Collection housed at the Smithsonian Institution's National Museum of Natural History (Washington, DC). This anatomical collection is composed primarily of individuals who died in the St. Louis area during the first half of the 20th century (Hunt and Albanese, 2005).

Trapezoids ($n = 192$) were also examined from 99 skeletons from late 20th – early 21st century Thai. The sample, consisting of 49 females (26–63 years of age) and 50 males (22–59 years of age), was derived from the bone collection room of the Forensic Osteology Research Center, Faculty of Medicine at Chiang Mai University (Chiang Mai, Thailand). The collection consists of self-donated