

Review Article

The prevalence of absent anterior facet of the calcaneus and a suggested convention for the naming of the configuration of the superior facets of the calcaneus

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ABSTRACT

Background: The superior surface of the human calcaneus will frequently demonstrate 3 articular facets for articulation with the talus: the posterior, middle and anterior facets. All calcanei possess a posterior and middle facet. However, not all calcanei possess an anterior facet. The main purpose of this article is to identify by literature review the prevalence of calcanei which do not have an anterior facet. With review, the discrepancy by authors in nomenclature for the various types of facets on the superior surface of the calcaneus becomes quite evident. Thus, a secondary purpose of this article is to recognize the need for a standard naming convention and propose an intuitive naming scheme for the calcaneal facet types.

Results: Of the 41 articles reviewed which are written in the English language and which describe absent anterior facet as a calcaneal facet type, the prevalence of calcanei lacking an anterior facet ranges from 3.3% to 4.9%. This difference in prevalence reporting depends on whether one allows "small anterior facet" specimens to be included in the total Type 3 (absent anterior facet) count. The prevalence also depends on whether data is included if an article could be considered an outlier. The total range of prevalence of absent anterior facet varies by article from 0% to 18%.

Conclusion: The prevalence of absent calcaneal anterior facet is approximately 4%. Studies in the future are needed to determine whether the absent anterior facet is 1) a normal finding, 2) is helpful for the foot, or 3) is pathologic for the foot. A visually intuitive naming system of the types of calcaneal facets is proposed so as to reduce confusion in this field of study, therefore likely reducing errors.

KEY WORDS: Absent anterior facet, calcaneal facet configuration, calcaneal facet types, subtalar joint.

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INTRODUCTION

The calcaneus is the largest bone of the human foot. The articular surfaces between the calcaneus and the talus determine the subtalar joint, which is mainly responsible for inversion and eversion of the foot. Most calcanei possess an anterior facet. The primary aim of this article is to determine what percentage of calcanei in the population do

not have an anterior facet. For this article, we review the 4 types of calcaneal facet configurations, shown in Figure 1, but for this study we will concentrate mainly on the Type 3, absent anterior facet (AAF) configuration.

The current author suggests that naming of the superior calcaneal articular facets in the manner shown in Figure 2 demonstrates an intuitive progression. If one observes the

anterior and middle facet configurations in relation to each other, the progression from 1A to 2D somewhat resembles division and separation of cells in cellular mitosis. The naming of facet configurations in this manner is proposed as a convention in order to standardize the nomenclature.

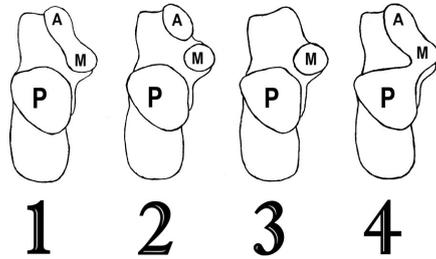


Fig. 1: Facets, superior surface of the calcaneus. P=posterior facet, M=middle, A=anterior facet. **Type 1:** the middle and anterior calcaneal facets are fused. **Type 2:** the middle and anterior facets are separate. **Type 3:** the anterior facet is absent/missing. **Type 4** is defined as: the posterior and middle facets are fused, with or without fusion or absence of the anterior facet. Published with permission of IJAR.

Many authors separate Types 1 and 2 into subtypes. The form of each subtype is summarized by this author in Figure 2.

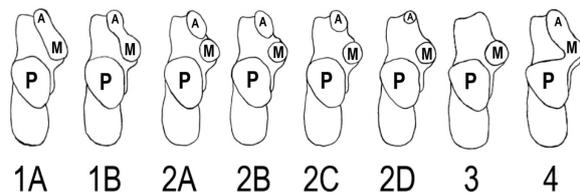


Fig. 2: Calcaneal types, including sub-types. Shown in a linear graphic fashion. 1A=non-constricted. 1B=constricted. 2A=separation of the anterior and middle facets less than 2 mm. 2B=separation of A and M 2-5 mm. 2C=A-M separation >5mm and up to 10mm. 2D=separation of anterior and middle facets >10mm. 3=absent anterior facet. 4=fused posterior and middle facets.

METHODS

The literature was searched for articles describing the configuration of the articular facets of the superior calcaneus for articulation with the talus. In this review, three aspects of each article were considered important: A) the motivation for the author to publish their results, B) the names the author gave for the calcaneal articular facet types and C) the number of absent anterior facet specimens compared to the total number of specimens in each study. Actual photographs of Type 2 and Type 3 wet cadaveric specimens are

submitted for viewing.

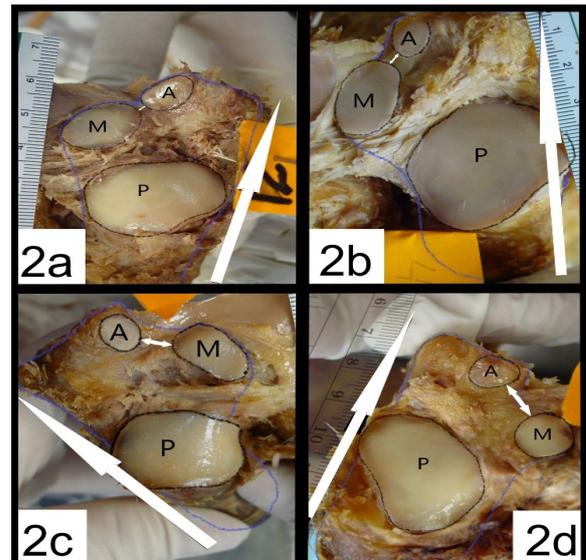


Fig. 3: Cadaveric Calcaneal Type 2 specimens. For point of reference, note the long white arrows located adjacent to the lateral wall of the calcaneus. These arrows are shown to assist the observers in establishing the calcaneal orientation from posterior to anterior. The blue lines delineate the extent of the calcaneal body. The white arrows demonstrate the measurement between the middle and anterior facets. P=posterior, M=middle, A=anterior facet. 2a: Right foot. The distance between the anterior and middle facets is less than 2 mm. 2b: Right foot. The distance between A and M is 2-5 mm. 2c: Left foot. The A-M distance is > 5 and up to 10 mm. 2d: Left foot. The A-M distance is greater than 10 mm.

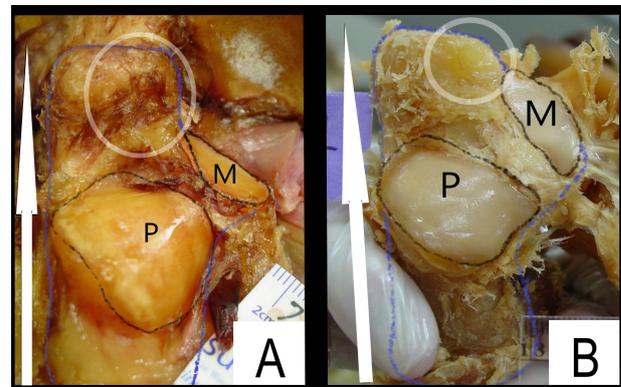


Fig. 4: Cadaveric Calcaneal Type 3 specimens. Two examples. P=posterior, M=middle facet. Both specimens are of the left foot. The long white arrows adjacent to the lateral calcaneal wall are shown to establish the posterior/anterior orientation. The blue lines delineate the extent of the calcaneal body. The white circles show where the anterior facets are expected to be, but are not present. Note in A the longer distance between the middle facet and the most anterior aspect of the calcaneus compared to the shorter distance in B. The photographs presented in Figures 3 and 4 were reviewed and collected from a study performed by a team of students, residents and attending physicians in May 2006, 2007, 2008 at SCPM, Dr. William M. Scholl College of Podiatric Medicine at Rosalind Franklin University of Medicine and Science. The

Ref #	AAF articles	year	%	name	AAF	SPEC#	Mot1	Mot2
26	Agarwal	2016	5.52	III	32	580	P	J
20	Anbumani	2017	3.6	C	4	110	S	p,j
29	Anjaneyulu	2014	5	B	5	100	j	
30	Artkengkla	2015	1	C	2	200	g	l
21	Barbaix	2000	10.4	B3	14	134	S	
3	Barki -Pakistan	2010	0	3	0	350	R	g
12	Boyan	2016	3.5	A4	2	57	O	
22	Bruckner	1987	9.4	D	3	32	S	
32	Campos-Pellico	1989	6.8	A4	12	176	A	
31	Chavan	2014	6.66	III	4	60	L	o
23	Drayer-Verhagen	1993	18.8	3	36	191	S	j
4	El-Eishi -Egypt	1974	11	3	22	200	R	a
5	Garg-India	2013	1.3	III	4	310	R	j
33	Gindha -N India	2015	0.31	IIC	1	325	A	
33 B	Gindha VSF	2015	9.2	IIIB	30			
6	Gupta-India	1977	5.2	3	21	401	R	A
13	Hyer	2002	2.9	M	22	755	O	
14	Iamsaard	2015	0	3	0	396	O	l
14 B	Iamsaard VSF	2015	8.84	2d	35			
7	Jha -Indian	1972	2.9	B4	46	1600	R	a
27	Kori (Andhra)	2016	3.67	III	22	600	P	j
15	Kullar	2015	1.5	III	3	200	O	s,j
25	Kumar	2017	5	A4	10	200	S	r
45	Laidlaw	1905	0.9	M	7	750	A	
8	Laxmi	2018	4	III	2	50	R	f
34	McShane	2020	5.1	3	8	158	A	
35	Mini	2012	0	A4	0	50	A	r
28	Muthukumaravel	2011	0	III	0	237	J	
9	Nagar	2012	1.1	B4	6	529	R	
24	Nemade	2014	9.1	III	20	220	S	j
19	Parimala	2016	2.3	4	2	88	F	s
16	Patel/Patel	2013	4.4	3	9	205	O	J
17	Pratap	2017	3.2	D	32	1000	O	j
18	Ragab -USA	2003	5.8	M	61	1056	O	
36	Ranganath(Priya)	2006	7	III	5	71	A	
37	Saadeh-Egypt	2000	4.7	III	14	300	A	
38	Sarvaiya	2012	4.8	A4	12	250	A	
39	Seema	2012	7	3	21	300	A	
40	Shahabpour	2011	10.2	B3	5	49	A	
41	Sharada	2012	3	3	9	300	A	
41 B	Sharada VSF	2012	2.3	2d	7			
10	Tahir	2008	0	3	0	350	R	g
11	Ukoha	2017	12.7	3	28	220	R	f
42	Uygur-Turkish	2009	5	A4	11	221	A	
	TOTAL				589	13381		

Table 1: Type 3 names given by authors, the percentages of AAF specimens, and author motivations. AAF=absent anterior facet. VSF=small or very small anterior facet. SPEC # is the total number of specimens in each article/study. Thus, note that in the three VSF rows (33B,14B,41B) the SPEC # is left blank so as to not count the total specimens twice. The name column reflects the name given by each author for the Type 3 (absent anterior facet) category. Mot1 is the motivation judged to be primary in the article and Mot2 is a secondary motivation for an author to do the study.

Table 1 KEY for the Motivation Column. A=anatomic study; F=fracture; G=gender Male/Female; J=joint pain/arthritis; L=laterality Right/Left; O=operative concerns/surgery; P=osteophyte; R=race/ethnicity; S=stability. Primary motivations are capitalized, secondary motivations are lower case.

photographs submitted in Figures 3 and 4 reflect well on the graphic description of specimen types shown in Figure 2. Note in Figure 4 the white circles showing where the anterior facets should be, but instead they are completely absent.

Motivations given in the literature by authors for performing their study: A selection of 41 international articles were chosen for this study if they were published in the English language and if the author reported the presence or absence of the anterior facet. As it turns out, the author motivation for studying calcaneal facet configuration is diverse. Most of the modern study in facet configuration began in 1963-1965 with the Bunning/Barnett [1,2] articles, of which the authors were attempting to show that the difference in types of calcaneal facets for the talus were related to ethnicity, race or sex. This was followed with many other authors attempting the same correlation with race, ethnicity or ethnic regions [3-11]. Table 1 lists the different motivations in tabular form.

Note the Mot 1 and Mot 2 columns for primary motivations and secondary motivations, respectively. Other motivations for studying the calcaneal facets include: **A)** concern for what calcaneal surgical osteotomies can or should be performed with certain types of calcaneal configurations [12-18], **B)** concern regarding how to properly treat calcaneal fractures [8,11,19], **C)** subtalar joint (STJ) stability or instability inherent with certain facet configurations [15,19-25], **D)** attempt at correlating calcaneal spurs with the superior calcaneal facet configurations [20,26,27], **E)** attempt at correlating facet configurations with arthritis [5,15-17,20,23,24,26-29], **F)** attempt to link facet configurations with male/female differences [3,10,30], and **G)** attempt to correlate with right/left differences [14,30,31]. The motivation for the remaining authors was mainly for the advancement of anatomical knowledge [32-42]. Unfortunately, some articles did not report the category of Type 3, absent anterior facet [1,2,43,44]. The first author reporting the absence of anterior facet (AAF) was apparently Laidlaw in 1902 [45], but this was

before the AAF category was established by later authors. The first author to report the AAF configuration as a separate category was Jha [7] in 1972, with 2.9% prevalence.

The different names given for Type 3 configurations in the literature: To understand the urgent need for the use of standard nomenclature, one only needs to observe the previously used different names of just the Type 3 configurations by authors in this field. Again, see Table 1 which lists the names given by various authors for the AAF type. A total of eleven different names were used by authors for the AAF category. However, thirteen different names were used if one includes the **small anterior facet** category in the count. To summarize from the table, 11 authors used the name **Type 3**, one used **Type 4**, 6 authors used **A4**, one author used **B**, 2 used **B3** and 2 called the category **B4**. Two authors used the name **C**, 2 used **D** for the AAF category, one author used **IIC**, 10 authors used the name **III**, three described the calcanei as **absent anterior facet** directly [13,18,45] which is listed in Table 1 as "M" because the author mentioned the absence without listing a type. If the category of **small or very small** was used, it was named **2d** by 2 authors and **IIIB** by one author. As published previously; to quote Priya Ranganath [36] on the current state of confusion of terms: "Meaningful comparative studies require a uniform system in the morphometric studies of the calcanei of the various population groups." And also: "It is shown ... that too many authors use too many naming schemes for describing calcaneal facet configuration" [34].

RESULTS AND DISCUSSION

Table 1 lists in tabular form the AAF prevalence results. The percentage of absent anterior facet of each study is reported in the % column. The number of specimens having an absent anterior facet are listed in the AAF column. The total number of specimens reported in each article is listed in the SPEC# column. The results when tabulating the prevalence of AAF from the articles reviewed depends on whether one A) includes or excludes the "very small facet" category or B) includes or excludes the high or low "outliers".

See the summary below. Regarding outliers: Since the overall AAF prevalence seems to be approximately 4-5%, then an article reporting over 10%, [4,11,21,23,40] may be considered too high or an article reporting 0% [3,10,14,28,35] may be considered too low. Both the high and low articles are entertained as being outliers. Please understand that this author is not claiming that the data collected by any of the authors is suspect or invalid. The articles described as outliers may reflect the normal and correctly observed and reported distribution in their global area. This author is simply describing the possible methods of including or excluding data if this data is reviewed critically by others. The summary below attempts to address these other reviewer's concerns if a critic would have a more *inclusive* versus a more *exclusive* tendency for accepting the data.

With three variables, there are 6 possible permutations recognized in reporting the AAF results. A-D reflects **including** the "high >10%" [4,11,21,23,40,] outliers, E-H **excludes** the high outliers. **A.** If one excludes the 72 specimens from the articles reporting "very small facets" of Iamsaard, Gindha, and Sharada [14,33,41] **and** includes the 'no AAF' articles Barki [3], Tahir [10], Iamsaard [14], Muthukumaravel [28] and Mini [35], then the AAF/total number is 517/13381=3.9%. **B.** If one excludes the VSF specimens **and** excludes the 1383 specimens in the 'no AAF' articles [3,10,14,28,35] then 517/11998=4.3%. **C.** If one includes the 72 VSF specimens and includes the 'no AAF', thus AAF/total is 589/13381=4.4%. **D.** If one includes the VSF specimens and excludes the 1383 specimens in the 'no AAF' articles, then 589/11998=4.9%. **E-H.** Finally, excluding high outliers over 10% (105 AAF/794 total) for El-Eishi, Barbaix, Drayer-Verhagen, Shahabpour, Ukoha [4,11,21,23,40] **and** excluding or including the VSF specimens **and** including or excluding the "no AAF" specimens in a similar manner to A-D will yield the results shown in the summary for E-H. These addition and subtraction numbers are imbedded in the data shown in Table 1.

Summary:

A: Include >10, Exclude VSF, Include no AAF:

517/13381 3.9%

B: Include >10, Exclude VSF, Exclude no AAF:
517/11998 4.3%

C: Include >10, Include VSF, Include no AAF:
589/13381 4.4%

D: Include >10, Include VSF, Exclude no AAF:
589/11998 4.9%

E: Exclude >10, Include VSF, Exclude no AAF:
484/11204 4.3%

F: Exclude >10, Exclude VSF, Exclude no AAF:
412/11204 3.7%

G: Exclude >10, Include VSF, Include no AAF:
484/12587 3.8%

H: Exclude >10, Exclude VSF, Include no AAF:
412/12587 3.3%

DISCUSSION

The first reporting of the prevalence of anterior facet absence was given by Laidlaw [45] in 1905, reporting the prevalence as being 0.9%. For many years, this AAF prevalence number was considered insignificant. Now that more recent authors are actively looking for and reporting the absent anterior facet configuration, the reported prevalence has risen significantly. The clinical significance of persons not having an anterior facet has not been studied. Thus, we do not know if the anterior facet absence is pathological or helpful or normal for the foot. More study is needed to investigate the absent anterior facet (Type 3) category with respect to its clinical impact on the human foot.

CONCLUSION

First: The prevalence of the absence of the anterior facet of the calcaneus as measured by this literature review appears to be approximately 4%. This 4% is not insignificant. Current literature review of author motivation in performing each study suggests possible clinical importance if one does not have an anterior facet. However, these clinical suggestions have largely not been proven and the clinical implications of this prevalence remains unknown.

Second: A standard naming convention regarding the configuration of the facets is needed to advance science in this field. The

current author suggests a graphically intuitive naming scheme in which the anterior and middle facets of the calcaneus appear to be dividing and separating from each other when going from Type 1A to Type 3 configurations. This author encourages future authors to voluntarily utilize this naming system so as to promote a standardized naming system for all types of facet configurations on the superior aspect of the calcaneus. Universal use of this convention would be expected to lessen confusion between authors and decrease the likelihood of errors in the study and reporting of the calcaneal configuration types.

Abbreviations

AAF: absent anterior facet of the calcaneus

No AAF: articles which report that there were no specimens missing an anterior facet in their study

VSF: small or very small anterior facet

STJ: subtalar joint

SCPM: Scholl College of Podiatric Medicine, N. Chicago IL, USA

Mot 1: primary motivation for performing the study

Mot 2: secondary motivation for performing the study

SPEC#: Total number of specimens in the author's study

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Conflicts of Interests: None

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