Section: Anatomy

Systematic Review

CALCANEAL TALAR ARTICULAR FACET MORPHOLOGY AND ITS ASSOCIATION WITH CALCANEAL SPUR FORMATION: A SYSTEMATIC REVIEW

Suvarna Gulanikar[1], Gajanan Bhanudas Padmawar[2], Gopal Bagal[3]

[1]Associate Professor, Department of Anatomy, R K Damani Medical College, Shri Ramchandra Institute of Medical Sciences (SRIMS), Chhatrapati Sambhajinagar, Maharashtra, India.
[2]Associate Professor, Department of Anatomy, ACPM Medical College, At Post: Morane, Sakri Road, Dhule, Maharashtra, India.
[3]Professor and Head, Department of Anatomy, R K Damani Medical College, Shri Ramchandra Institute of Medical Sciences (SRIMS), Chhatrapati Sambhajinagar, Maharashtra, India.

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Corresponding Author:
Dr. Gajanan Bhanudas Padmawar,
Associate Professor, Department of Anatomy, ACPM Medical College, At Post: Morane, Sakri Road, Dhule, Maharashtra, India..
Email: drgajananp@gmail.com

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ABSTRACT

Background: Calcaneal spur formation may be influenced by biomechanical loading and anatomical variation in the subtalar joint. Variations in calcaneal talar articular facet morphology, particularly continuity or fusion of the anterior and middle facets, may alter force transmission through the calcaneus, but their relationship with calcaneal spur formation remains uncertain. The objective is to systematically review the anatomical evidence on the association between calcaneal talar articular facet morphology and calcaneal spur formation.
Materials and Methods: MEDLINE/PubMed, Embase, Scopus, Web of Science Core Collection, Google Scholar, and reference lists were searched from inception to 31 May 2026. Adult human anatomical studies evaluating both talar articular facet morphology and calcaneal spurs or enthesophytes were eligible. Owing to heterogeneity in facet classifications, spur definitions, and reporting formats, findings were synthesized narratively without meta-analysis.
Results: Seven dry-bone anatomical studies involving 2,171 adult calcanei were included, with individual sample sizes ranging from 34 to 600 calcanei. Six studies directly evaluated calcaneal spurs in relation to talar facet configuration, while one provided supportive enthesophyte data. Among studies with extractable morphology denominators, fused or continuous anterior-middle facets, generally classified as Type I or Pattern I, constituted approximately 66.36% to 78.7% of calcanei. Reported overall calcaneal spur prevalence in the six core studies ranged from 17.7% to 61.38%. Individual study prevalences were 26.5%, 39.33%, 17.7%, 61.38%, 31.77%, and 36.57%. Plantar spur prevalence ranged from 6.5% to 21.4% of the total study samples where separately reported. Spurs were repeatedly concentrated in Type I or Pattern I calcanei; however, this morphology was also the predominant background configuration, preventing inference that it independently increased spur risk.
Conclusion: Calcaneal spurs are frequently observed in calcanei with fused or continuous anterior-middle talar articular facets. However, because Type I or Pattern I morphology constituted approximately two-thirds to four-fifths of several study populations, the available evidence does not establish it as an independent predictor of spur formation. Standardized studies reporting morphology-specific denominators and separate plantar and posterior spur outcomes are required.
Keywords: Calcaneus; calcaneal spur; plantar calcaneal spur; heel spur; talar articular facet; subtalar joint; calcaneal morphology; enthesophyte; systematic review.

INTRODUCTION

Calcaneal spurs are bony outgrowths arising from the calcaneus and are commonly described at the plantar aspect, posterior aspect, or both.[1-5] Plantar calcaneal spurs are usually seen near the plantar surface of the calcaneal tuberosity, whereas posterior calcaneal spurs are related to the region of the tendoachilles insertion.[1,3,6] Although calcaneal spurs are frequently identified on radiographs and anatomical specimens, their clinical significance remains variable. They may be seen in individuals with heel pain, plantar fasciopathy, tendoachilles-related symptoms, or degenerative disease, but may also be present in asymptomatic individuals.[1,2,7-10] Therefore, the presence of a calcaneal spur should be interpreted as an anatomical or radiological finding rather than direct evidence of a symptomatic lesion.

The mechanisms responsible for calcaneal spur formation remain incompletely understood. Traditional explanations for plantar spurs have emphasized chronic traction at the plantar fascial attachment, while posterior spurs have been considered in relation to mechanical stress at the tendoachilles insertion.[3,6,11] However, traction alone does not fully explain all patterns of calcaneal enthesophyte formation. Histological, anatomical, and imaging studies have suggested that spur formation may also be influenced by repetitive microtrauma, degenerative enthesopathy, compressive loading, inflammatory change, ageing, obesity, osteoarthritis, and generalized osteophyte-forming tendency.[1,2,4,5,8,12] The occurrence of spurs in both symptomatic and asymptomatic individuals further supports the view that calcaneal spur formation is multifactorial rather than the result of a single mechanical pathway.

The calcaneus is the largest tarsal bone and has an important role in weight bearing, hindfoot stability, gait mechanics, and transmission of load between the talus and the ground.[13,14] Its superior surface articulates with the talus through anterior, middle, and posterior talar articular facets, which together form the osseous component of the subtalar joint.[14-16] Considerable anatomical variation exists in the number, shape, separation, and continuity of these facets.[15-20] The anterior and middle talar facets may be continuous or fused, completely separate, or arranged in less common configurations, including absence of the anterior facet or fusion involving other articular surfaces.[15,17,19,20]

These variations in talar articular facet morphology are clinically and biomechanically relevant because they may influence subtalar joint mechanics, hindfoot mobility, joint stability, ligamentous restraint, and the distribution of forces transmitted through the calcaneus.[16,18,21-23] A fused or continuous anterior-middle talar facet, commonly described as Type I morphology in several anatomical studies, may theoretically alter subtalar contact mechanics and modify the pattern of stress distribution within the calcaneus.[16,17,21] Such altered loading may contribute to bony adaptive change, degenerative change, or enthesophyte formation. However, the extent to which talar facet morphology is actually associated with calcaneal spur formation remains uncertain.

Several anatomical studies have examined calcaneal spurs in relation to talar articular facet configuration. Kullar et al. evaluated calcaneal enthesophytes in dry adult calcanei and reported spur occurrence according to calcaneal facet type.[24] Rajkohila et al. studied calcaneal spurs and lateral tubercular bars in dry calcanei and described plantar, tendoachilles, combined, and sustentaculum tali spurs according to talar facet pattern.[25] Kori et al. assessed variations in talar articular facets and their association with dorsal, plantar, and combined calcaneal spurs.[26] Agarwal et al. evaluated adult human calcanei and reported an association between articular facet configuration and calcaneal spur occurrence.[16] Other anatomical studies have similarly explored the relationship between talar facet morphology and calcaneal spurs or related bony outgrowths.[27,28]

A recurring observation in these studies is that calcaneal spurs are often reported most frequently in calcanei with fused or continuous anterior-middle talar facets.[16,24-28] This observation has led some authors to suggest a possible relationship between Type I morphology and spur formation. However, interpretation of this finding requires caution. Type I morphology is also the most common background calcaneal configuration in many anatomical samples.[15,16,24-28] Therefore, a large absolute number of spur-bearing Type I calcanei may reflect the high prevalence of Type I morphology itself rather than a true independent association between this morphology and spur formation.

The available evidence is also limited by methodological heterogeneity. Published studies differ in population origin, sample size, specimen source, classification system, spur terminology, and separation of plantar, posterior, dorsal, tendoachilles, and combined spurs.[16,24-28] Some studies provide separate data for plantar and posterior spurs, whereas others report calcaneal spurs collectively. In addition, most available studies are dry-bone anatomical investigations and therefore lack donor-level clinical information such as age, sex, body mass index, occupation, footwear, physical activity, diabetes, inflammatory disease, osteoarthritis, foot posture, heel pain, or tendoachilles symptoms. These limitations restrict causal interpretation and make it difficult to determine whether talar facet morphology independently contributes to spur development.

A systematic review of this topic is therefore warranted. Previous literature has addressed the anatomy, histology, aetiology, and clinical associations of calcaneal spurs, particularly plantar calcaneal spurs.[1,2] However, the specific relationship between calcaneal talar articular facet morphology and calcaneal spur formation has not been synthesized as a focused anatomical question. A structured review may help distinguish consistent anatomical patterns from findings that are driven by background morphology distribution or inconsistent reporting.

The present systematic review was undertaken to evaluate the available anatomical evidence on the association between calcaneal talar articular facet morphology and calcaneal spur formation. The review aimed to summarize how plantar, posterior/dorsal, tendoachilles, and combined calcaneal spurs have been reported across different talar facet configurations, with particular attention to fused or continuous anterior-middle facet morphology, while critically assessing whether current evidence supports an independent relationship between facet configuration and spur development.

MATERIALS AND METHODS

Search strategy: This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.29 A systematic literature search was performed in MEDLINE/PubMed, Embase, Scopus, and Web of Science Core Collection from database inception to 31 May 2026. Additional searches were performed using Google Scholar to identify relevant articles not retrieved through the electronic database search. The reference lists of included studies and relevant review articles were also screened manually for additional eligible studies.

The search strategy combined terms related to the calcaneus, talar articular facet morphology, subtalar joint morphology, and calcaneal spur formation. The following search terms were used in different combinations according to the requirements of each database: "calcaneus," "calcaneum," "calcaneal morphology," "calcaneal morphometry," "talar articular facet," "talar facet," "articular facet," "facet configuration," "subtalar joint," "calcaneal spur," "plantar calcaneal spur," "plantar spur," "dorsal spur," "posterior calcaneal spur," "heel spur," "calcaneal enthesophyte," "enthesophyte," and "bony spicule."

An illustrative PubMed search strategy was: (calcaneus OR calcaneum OR calcaneal) AND ("talar facet" OR "talar articular facet" OR "articular facet" OR "facet configuration" OR morphology OR morphometry OR "subtalar joint") AND ("calcaneal spur" OR "plantar calcaneal spur" OR "plantar spur" OR "dorsal spur" OR "posterior calcaneal spur" OR "heel spur" OR enthesophyte OR "bony spicule")

No restriction was applied regarding year of publication. Only full-text articles published in English were considered for inclusion. When multiple publications appeared to report overlapping anatomical material or duplicate datasets, the most complete and relevant dataset was selected.

Eligibility criteria: Studies were eligible if they examined adult human calcanei and evaluated calcaneal talar articular facet morphology in relation to calcaneal spur formation. Cross-sectional anatomical studies of dry calcanei, cadaveric studies, and imaging-based observational studies were considered eligible if they assessed both talar articular facet morphology and calcaneal spur or enthesophyte occurrence in the same study population.

Studies were included if they reported the distribution of talar articular facet morphology and provided information regarding calcaneal spurs, enthesophytes, or related bony outgrowths according to facet configuration, or if they otherwise evaluated an association between facet morphology and calcaneal spur formation.

The exposure of interest was calcaneal talar articular facet morphology, including the number, continuity, fusion, separation, or absence of the anterior, middle, and posterior talar articular facets. Particular attention was given to morphology characterized by continuity or fusion of the anterior and middle talar articular facets with a separate posterior facet, commonly described as Type I morphology in several anatomical studies. Because classification systems varied between studies, morphological categories were interpreted according to their anatomical descriptions rather than solely according to the numerical type labels assigned by individual authors.

The primary outcome of interest was calcaneal spur formation. Where reported, spur location was extracted separately as plantar, dorsal, posterior, tendoachilles-related, sustentaculum tali, combined plantar-dorsal, combined plantar-tendoachilles, or other described bony outgrowths. Studies using broader terms such as enthesophytes or bony spicules were included only if these findings were reported in relation to calcaneal morphology, and their terminology was preserved during synthesis.

Studies were excluded if they were reviews, editorials, letters, case reports, conference abstracts without sufficient data, non-human studies, paediatric studies, studies of immature calcanei, studies examining talar facet morphology without any calcaneal spur or enthesophyte data, or studies reporting calcaneal spurs without assessment of talar articular facet morphology.

Study selection: All records identified through the literature search were exported to reference-management software, and duplicate citations were removed. Titles and abstracts were screened independently by two reviewers. Articles considered potentially eligible by either reviewer were selected for full-text assessment.

The full texts of potentially eligible articles were then assessed independently against the predefined eligibility criteria. Disagreements regarding study eligibility were resolved through discussion and consensus. If consensus could not be reached, a third reviewer was consulted. The study-selection process was documented using a PRISMA flow diagram.

Data extraction: Data were extracted independently by two reviewers using a standardized data-extraction form. Extracted study characteristics included first author, year of publication, country or geographical population, study design, source of calcaneal specimens, total number of calcanei examined, side distribution where available, age and sex information where reported, method of anatomical assessment, classification system used, and definitions of individual talar facet configurations.

Morphology-related data included the number or proportion of calcanei in each talar facet configuration, anatomical description of the anterior, middle, and posterior facets, presence or absence of fusion between facets, separation between facets where reported, absent facets, uncommon configurations, and any additional morphometric details relevant to subtalar or calcaneal morphology.

Spur-related data included the total number of calcaneal spurs or spur-bearing calcanei, location of spurs where reported, number of plantar spurs, number of dorsal or posterior spurs, number of tendoachilles-related spurs, number of combined spurs, number of sustentaculum tali spurs, number of enthesophytes or bony spicules where those terms were used, and the distribution of these findings according to talar facet morphology.

The anatomical definition of each facet category was checked before comparing findings across studies. A numerical category label such as “Type I” was not assumed to be equivalent between studies unless the anatomical description corresponded to the same facet configuration. Where terminology differed, the original authors’ terminology was retained and interpreted descriptively.

No unreported data were created. When a study did not provide sufficient numerical detail to determine spur distribution by facet type, this limitation was recorded and the study was summarized qualitatively. Any discrepancies in extracted data were resolved by comparison with the original article and discussion between reviewers.

Quality appraisal: Methodological quality and risk of bias were assessed using an anatomy-focused approach based on the Anatomical Quality Assessment tool.30 The assessment considered the clarity of study objectives, specimen characteristics, study design, anatomical methods, definition of talar facet categories, definition of spur or enthesophyte findings, completeness of numerical reporting, and appropriateness of interpretation.

Two reviewers independently assessed each included study. Particular attention was given to whether the source of calcanei was described, whether age and sex of specimens were available, whether facet morphology was defined clearly, whether spur location was recorded separately, whether complete denominator data were provided for each facet type, and whether observer reliability was reported. Disagreements were resolved by discussion and consensus, with consultation of a third reviewer when necessary.

Risk-of-bias findings were not converted into numerical summary scores. Instead, methodological strengths and limitations were summarized narratively and incorporated into the interpretation of the evidence.

Data synthesis: Because the included studies were expected to differ in anatomical population, specimen source, classification system, spur terminology, and reporting format, the findings were synthesized narratively. No quantitative meta-analysis was performed.

The synthesis was organized around the following domains: distribution of talar articular facet configurations, frequency of calcaneal spurs or related bony outgrowths, distribution of spurs according to facet morphology, consistency of reported associations across studies, and methodological limitations affecting interpretation.

Where individual studies reported spur location separately, plantar, dorsal, posterior, tendoachilles-related, sustentaculum tali, and combined spurs were described separately. Where studies used broader terminology such as enthesophytes or bony spicules, those terms were retained rather than reclassified as plantar or posterior spurs unless the original article clearly specified the location.

Particular attention was given to the distinction between numerical predominance and proportional association. If spurs were reported most frequently in a particular facet type, this was interpreted in light of the background frequency of that facet type within the study sample. This was considered important because fused or continuous anterior-middle facet morphology was often the most common calcaneal configuration in anatomical collections.

The calcaneus was considered the unit of analysis because the included anatomical studies generally reported findings per bone rather than per donor. The absence of donor-level clinical information, including age, sex, body mass index, occupation, symptoms, foot posture, systemic disease, and loading history, was considered during interpretation.

The final synthesis was presented using structured tables and narrative comparison. Findings were not pooled statistically because of heterogeneity in classification methods, outcome definitions, and completeness of morphology-specific spur reporting.

RESULTS

Study selection: The study-selection process is summarized in [Figure 1]. The search identified 620 records through database and Google Scholar searching: PubMed/MEDLINE, Embase, Scopus, Web of Science Core Collection, and the first 200 Google Scholar results. An additional 41 records were identified through citation searching and hand-searching of relevant Indian anatomy journals. Before screening, 249 database records were removed because of duplication, automated ineligibility marking, or other reasons.

After these removals, 371 database records were screened by title and abstract, of which 326 records were excluded because they were not related to the calcaneus or subtalar joint, involved animal or fetal material, or addressed unrelated pathology. From database and Google Scholar searching, 45 reports were sought for retrieval, of which 4 reports could not be retrieved. The remaining 41 reports were assessed for eligibility. Of the 41 records identified by other methods, 27 were excluded at title and abstract screening; 14 reports were sought for retrieval, of which 2 reports could not be retrieved. The remaining 12 reports were assessed for eligibility.

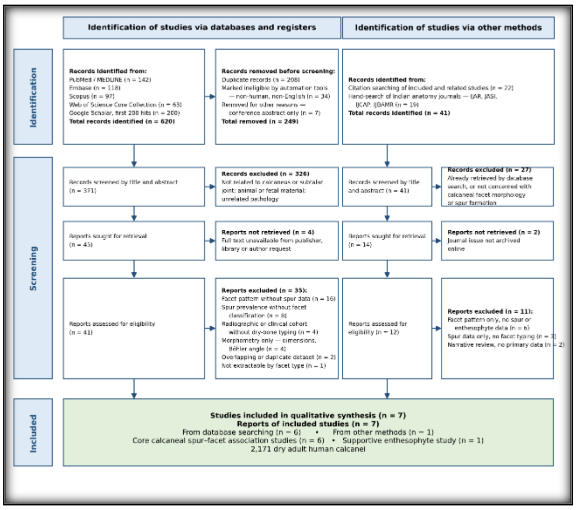

Figure 1: PRISMA flow diagram showing the identification, screening, eligibility assessment, and inclusion of studies in the systematic review.

After full-text eligibility assessment, 46 of the 53 reports were excluded: 22 reported facet patterns without spur data, 11 reported spur prevalence without facet classification, 4 were radiographic or clinical cohorts without dry-bone facet typing, 4 reported morphometry-only outcomes, 2 used overlapping or duplicate datasets, 1 did not permit extraction of facet-type data, and 2 were narrative reviews without primary data.

The final qualitative synthesis included seven anatomical studies that evaluated calcaneal talar articular facet morphology together with calcaneal spur, calcaneal enthesophyte, or related bony outgrowth formation. Six studies directly assessed calcaneal spurs in relation to talar articular facet configuration, while one study was included as supportive anatomical evidence because it evaluated calcaneal facet morphology together with enthesophytes.

All included studies were observational anatomical studies based on dry adult human calcanei. No included study was an imaging-based clinical study. Because the studies differed in anatomical population, sample size, classification system, terminology for spurs or enthesophytes, and completeness of morphology-specific reporting, the findings were synthesized narratively. No quantitative meta-analysis was performed.

Characteristics of included studies: The seven included studies examined a total of 2,171 dry adult human calcanei. Individual sample sizes ranged from 34 to 600 calcanei.

Kullar et al. studied 200 dry adult calcanei and evaluated calcaneal enthesophytes according to calcaneal type.[24] Rajkohila et al. studied 300 dry human calcanei and assessed plantar, tendoachilles, combined, and sustentaculum tali spurs in relation to talar facet pattern.[25] Kori et al. examined 600 dry calcanei of unknown age and sex and evaluated variations in talar articular facets together with dorsal, plantar, and combined calcaneal spurs.[26] Agarwal et al. studied 580 adult human calcanei and assessed the relationship between articular facet configuration and calcaneal spur presence.[16] Biswal et al. examined 107 dry adult calcanei and analysed calcaneal spurs according to talar articular facet morphology.[27] Vaishnav et al. studied 350 dry adult calcanei of unknown age and sex and evaluated calcaneal spur occurrence in relation to talar articular facet configuration.[28] Prakash and Viveka examined 34 dry calcanei and reported calcaneal facet morphology together with enthesophytes.[31]

The evidence base was geographically limited, with all included studies arising from Indian anatomical samples. Most studies used gross anatomical examination of dry bones. Donor-level clinical information such as age, sex, body mass index, occupation, symptoms, footwear, physical activity, diabetes, inflammatory disease, osteoarthritis, and loading history was generally unavailable.

Table 1: Characteristics of included studies

Study	Country / population	Study design	Sample	Specimen / assessment method	Facet morphology assessed	Spur / bony outgrowth assessment	Role in synthesis
Kullar et al., 2014	India; Punjab	Cross-sectional anatomical study	200 dry adult calcanei	Gross anatomical examination; 100 right and 100 left dry adult calcanei of unknown age and sex	Calcanei classified according to talar articular facets	Dorsal, plantar and combined dorsal–plantar calcaneal spurs recorded	Core study
Rajkohila et al., 2016	India; South Indian anatomical sample	Cross-sectional anatomical study	300 dry human calcanei	Gross anatomical examination; 142 right and	Calcanei classified according to talar facet pattern	Plantar, tendoachilles, combined plantar–tendoachilles and	Core study

				158 left calcanei of unknown sex		sustentaculum tali spurs recorded	
Kori et al., 2016	India; North Indian population	Cross-sectional anatomical study	600 dry calcanei	Gross anatomical examination of calcanei of unknown age and sex	Five talar facet types, with Type I and Type II subtypes	Dorsal, plantar and combined dorsal–plantar calcaneal spurs recorded	Core study
Agarwal et al., 2016	India; New Delhi	Cross-sectional anatomical study	580 adult human calcanei	Gross anatomical examination; 280 right and 300 left adult calcanei of Indian origin	Five articular facet patterns; interfacet distance and angle of intersection also measured	Dorsal, plantar, combined dorsal–plantar and anterior spurs recorded; overall association with facet configuration tested	Core study, but not fully plantar-specific by facet type
Biswal et al., 2018	India; Odisha	Cross-sectional anatomical study	107 dry adult calcanei	Gross anatomical examination; 55 right and 52 left calcanei of unknown sex	Four talar facet types	Plantar, dorsal, combined dorsal–plantar and sustentaculum tali spurs recorded	Core study
Vaishnav et al., 2022	India; Gujarat anatomical sample	Cross-sectional anatomical study	350 dry adult calcanei	Gross anatomical examination of dry adult calcanei of unknown age and sex	Four talar facet types	Plantar, dorsal and combined dorsal–plantar spurs recorded	Core study, but complete facet-type denominators not clearly extractable from available text
Prakash and Viveka, 2016	India	Cross-sectional anatomical and morphometric study	34 dry calcanei	Gross anatomical and morphometric examination	Talar facet pattern and cuboidal facet measurements	Enthesophytes recorded	Supportive study only

Talar articular facet morphology: Most included studies classified calcanei according to the configuration of the anterior, middle, and posterior talar articular facets. The most frequently discussed pattern was a fused or continuous anterior-middle talar articular facet with a separate posterior facet, commonly described as Type I or Pattern I morphology.16,24-28

Kullar et al. reported Type I morphology as the most frequent calcaneal type, accounting for 72.5% of their sample.24 Rajkohila et al. described four calcaneal types and defined Type I as one continuous anterior and middle facet.25 Kori et al. classified calcanei according to talar facet variation and reported Type I morphology as the predominant configuration.26 Agarwal et al. reported Pattern I morphology, defined by fused anterior and middle facets, in 66.55% of 580 calcanei.16 Biswal et al. similarly evaluated calcanei according to talar articular facet type in an Odisha population.27 Vaishnav et al. classified calcanei according to talar articular facet morphology and compared these types with calcaneal spur occurrence.28

Although the broad distinction between fused and separate anterior-middle facets was consistent across several studies, classification systems were not identical. Some studies used four-type systems, while others used five-pattern classifications or additional subtypes. Therefore, facet categories were interpreted according to their anatomical description rather than numerical type label alone.

Table 2: Distribution of calcaneal talar articular facet morphology Calcaneal spur and enthesophyte findings

Study	Total calcanei	Type / Pattern I	Type / Pattern II	Type / Pattern III	Type / Pattern IV	Type / Pattern V	Notes
Kullar et al., 2014	200	72.5%	NR	NR	0.5%	Not used	Type I was maximum; Type IV was least frequent
Rajkohila et al., 2016	300	78.7%	NR	NR	1.3%	Not used	Type I was predominant; Type IV was least frequent
Kori et al., 2016	600	442; 73.9%	130; 21.5%	22; 3.67%	2; 0.3%	4; 0.6%	Type I was subdivided into Ia and Ib; Type II into IIa, IIb and IIc
Agarwal et al., 2016	580	66.55%	27.59%	5.52%	0.17%	0.17%	Pattern I = fused anterior and middle facets; Pattern II = all three facets separate
Biswal et al., 2018	107	71; 66.36%	23; 21.50%	11; 10.28%	2; 1.86%	Not used	Four-type classification
Vaishnav et al., 2022	350	NR	NR	NR	NR	Not used	Four-type classification described, but complete

							denominators by type were not clearly extractable from available text
Prakash and Viveka, 2016	34	NR	NR	NR	NR	NR	Supportive morphometric study; not used for direct facet-type comparison

Calcaneal spur frequency and reporting format varied across studies. Some studies reported plantar, dorsal or posterior, and combined spurs separately, whereas others reported calcaneal spurs collectively or used broader terminology such as enthesophytes.

Kullar et al. reported calcaneal spurs in relation to talar facet type and recorded plantar, dorsal, and combined dorsal-plantar spurs separately.[24] In that study, calcaneal spurs were reported most frequently in Type I calcanei, while no spurs were reported in Type III calcanei.[24]

Rajkohila et al. reported that 39.33% of 300 calcanei had spurs. The reported spur locations included plantar spurs, tendoachilles spurs, combined plantar-tendoachilles spurs, and sustentaculum tali spurs.[25] Plantar spurs were described as arising from the medial tubercle of the calcaneus.[25]

Kori et al. reported dorsal, plantar, and combined calcaneal spurs in relation to talar articular facet morphology.[26] Their study identified calcaneal spurs predominantly in Type I calcanei, while Type III and Type IV calcanei did not show dorsal or plantar spurs in their sample.[26]

Agarwal et al. reported calcaneal spurs in 356 of 580 calcanei, corresponding to 61.38%.[16] The authors found a statistically significant association between calcaneal spur presence and articular facet configuration.[16] However, because the study emphasized overall calcaneal spur presence rather than consistently separating plantar and posterior or dorsal spur distribution by each pattern, its findings were interpreted as evidence for calcaneal spur formation overall rather than plantar-specific spur formation.

Biswal et al. evaluated calcaneal spurs on the basis of talar articular facets in 107 dry adult calcanei.[27] The study reported spur occurrence in relation to facet morphology and distinguished plantar, dorsal, combined, and sustentaculum tali spurs.[27]

Vaishnav et al. studied 350 dry adult calcanei and reported calcaneal spur occurrence according to talar articular facet configuration.[28] The study reported plantar, dorsal, and combined spurs and found that spur-bearing calcanei were predominantly represented by Type I morphology.[28]

Prakash and Viveka reported enthesophytes in a smaller sample of 34 dry calcanei and found Pattern I morphology to be the most frequently encountered facet pattern.[31] Because this study used enthesophyte terminology and did not provide directly comparable calcaneal spur distribution by each facet type, it was interpreted as supportive anatomical evidence rather than as a core spur-distribution study.

Table 3: Calcaneal spur or enthesophyte findings reported in included studies

Study	Total calcanei	Total spur / enthesophyte frequency	Plantar spurs	Dorsal / posterior / tendoachilles spurs	Combined spurs	Other spur / bony outgrowth	Key reported relationship with facet morphology
Kullar et al., 2014	200	26.5%	6.5%	Dorsal: 15.5%	Dorsal + plantar: 4.5%	NR	Spurs were highest in Type I calcanei; no spurs were reported in Type III calcanei
Rajkohila et al., 2016	300	118 calcanei; 39.33%	45; 15%	Tendoachilles: 37; 12.33%	Plantar + tendoachilles: 33; 11%	Sustentaculum tali: 3; 1%	Calcaneal spurs were more commonly found in Type I calcanei
Kori et al., 2016	600	106; 17.7%	64; 60.4% of spur-bearing calcanei	Dorsal: 37; 35% of spur-bearing calcanei	Both: 5; 4.7% of spur-bearing calcanei	NR	Spurs were predominantly found in Type I calcanei; Types III and V had no spurs; Type IV had plantar spurs
Agarwal et al., 2016	580	356; 61.38%	80; 13.79%	Dorsal: 156; 26.90%	Dorsal + plantar: 119; 20.52%	Anterior spur: 1; 0.17%	Spur presence was significantly associated with facet configuration; Pattern I accounted for 43.62% of calcanei with spurs
Biswal et al., 2018	107	34; 31.77%	11; 10.28%	Dorsal: 20; 18.70%	Both: 3; 2.80%	Sustentacular spur: 1; 0.93% of all calcanei	Maximum spur frequency was reported in Type I calcanei
Vaishnav et al., 2022	350	128; 36.57%	75; 21.4%	Dorsal: 36; 10.2%	Both: 17; 4.8%	NR	Spur-bearing calcanei were most frequently Type I
Prakash and Viveka, 2016	34	NR	NR	NR	NR	Enthesophytes recorded	Supportive only; direct spur-type distribution by facet type was not used

Methodological quality of included studies: The included studies were generally relevant to the review question because they directly examined dry adult human calcanei and assessed talar articular facet morphology. However, methodological limitations were common. Most studies used skeletal material of unknown age and sex, and donor-level clinical information was generally unavailable. Reporting of spur location, facet-type denominators and observer reliability varied across studies. These limitations restricted interpretation of whether talar facet morphology was independently associated with calcaneal spur formation.

Association between facet morphology and calcaneal spur formation: Across the core studies, calcaneal spurs were commonly reported in calcanei with fused or continuous anterior-middle talar articular facets.[16,24-28] This pattern was repeatedly observed in dry-bone anatomical samples and represented the main anatomical signal identified in the review.

However, the strength of this association was difficult to determine. Type I or Pattern I morphology was also the most common background facet configuration in several included studies.[16,24-28] Therefore, a high absolute number of spur-bearing Type I calcanei did not necessarily indicate that Type I morphology independently increased the likelihood of calcaneal spur formation. In many studies, data were presented as the distribution of spurs among facet types, rather than as complete proportional comparisons showing the number of calcanei with and without spurs within each facet category.

Where morphology-specific spur distribution was reported, the findings were presented in different formats across studies. Some studies reported percentages of the total study sample, whereas others reported absolute counts according to facet type. Because complete denominator data were not consistently available for every facet category, these findings were interpreted descriptively and were not treated as direct proportional risk estimates.

The most consistent descriptive finding was therefore that calcaneal spurs were frequently observed in Type I or Pattern I calcanei, not that Type I morphology was definitively established as an independent risk factor. The available evidence supported a possible anatomical relationship between talar facet configuration and spur formation, but it did not allow a firm causal or predictive conclusion.

Reporting of plantar and non-plantar spurs: Several studies separated plantar spurs from other calcaneal spurs, which strengthened their relevance to location-specific interpretation. Kullar et al. reported plantar, dorsal, and combined spurs separately.[24] Rajkohila et al. reported plantar, tendoachilles, combined plantar-tendoachilles, and sustentaculum tali spurs separately.[25] Kori et al. reported dorsal, plantar, and combined spurs separately.[26] Biswal et al. distinguished plantar, dorsal, combined, and sustentaculum tali spurs.[27] Vaishnav et al. reported plantar, dorsal, and combined spurs.[28]

Nevertheless, the definitions and categories were not uniform. Some studies used the term dorsal spur, some referred to tendoachilles spurs, and others used enthesophyte or bony outgrowth terminology. Because plantar and posterior or tendoachilles-related spurs may differ in anatomical location and biomechanical mechanism, the findings were not treated as interchangeable unless the original study clearly specified the spur location.

Summary of results: The available anatomical evidence suggested that calcaneal spurs were frequently reported in calcanei with fused or continuous anterior-middle talar articular facets. However, because this morphology was also the predominant background configuration in several samples, the evidence did not establish it as an independent predictor of spur formation. The current literature supports a possible anatomical and biomechanical relationship between talar facet morphology and calcaneal spur formation, but the conclusion remains limited by dry-bone study design, heterogeneous classification systems, inconsistent spur terminology, and lack of donor-level clinical data

DISCUSSION

Principal findings: This systematic review evaluated the association between calcaneal talar articular facet morphology and calcaneal spur formation. The available evidence was derived predominantly from dry-bone anatomical studies, most of which were conducted in Indian skeletal populations. Across the included studies, calcanei with fused or continuous anterior and middle talar articular facets, commonly described as Type I or Pattern I morphology, were frequently represented among calcanei with spurs. This observation formed the main anatomical signal identified in the review.

However, this finding required cautious interpretation. Type I or Pattern I morphology was also the most common background calcaneal configuration in several included anatomical samples. Therefore, the frequent observation of spur-bearing Type I calcanei did not necessarily establish that this morphology independently increased the likelihood of calcaneal spur formation. The available evidence suggested a possible anatomical relationship between talar articular facet morphology and calcaneal spur formation, but it did not establish Type I morphology as an independent predictor.

Interpretation of the association between facet morphology and spur formation

Several included studies reported that calcaneal spurs were most frequently observed in calcanei with fused or continuous anterior-middle talar articular facets.[16,24-28] This observation has anatomical plausibility because the configuration of the talar articular facets may influence subtalar joint mechanics, hindfoot stability, ligamentous restraint, and stress distribution through the calcaneus.[16,20,21] A continuous anterior-middle facet may theoretically alter the pattern of talocalcaneal contact and modify the transmission of forces through the calcaneal body during weight bearing.

Nevertheless, the interpretation of this association is not straightforward. A high absolute number of calcaneal spurs in Type I calcanei does not necessarily imply that Type I morphology increases the proportional risk of spur formation. If Type I morphology is the most prevalent morphology in the underlying skeletal sample, many spurs will be expected to occur in Type I calcanei simply because most calcanei belong to that category. Therefore, morphology-specific denominator data are essential before inferring risk.

This distinction is central to the interpretation of the present review. Several primary studies reported the distribution of spurs among facet types, but fewer provided complete data showing the number of calcanei with and without spurs within each facet category. As a result, the literature more strongly supports the descriptive statement that calcaneal spurs are commonly observed in Type I calcanei than the stronger analytical claim that Type I morphology independently predisposes to spur formation.

Biomechanical considerations: The calcaneus is a major load-bearing bone and forms the inferior osseous component of the subtalar joint. Its morphology influences hindfoot alignment, subtalar movement, and the transmission of forces during standing and gait. Variation in the talar articular facets may affect the contact area between the talus and calcaneus, the degree of subtalar mobility, and the distribution of compressive and shear forces across the hindfoot.[14,16,20,21]

A fused or continuous anterior-middle talar facet may create a different pattern of subtalar contact compared with separate anterior and middle facets. Some authors have suggested that such configurations may be associated with altered subtalar stability, degenerative change, or altered mechanical loading.[16,21,23] These mechanisms provide a plausible anatomical explanation for the repeated observation that spur-bearing calcanei are commonly represented by Type I or Pattern I morphology.

However, calcaneal spur formation is likely multifactorial. Plantar spurs have been linked to traction at the plantar fascia origin, repetitive vertical compression, degenerative enthesopathy, ageing, obesity, osteoarthritis, and previous heel pain.[1,2,5,11,12] Posterior or tendoachilles-related spurs may involve different local mechanical factors related to the tendoachilles insertion. Therefore, talar facet morphology should be viewed as one possible structural contributor within a broader mechanical and degenerative environment rather than as the sole determinant of spur formation.

The absence of donor-level clinical information in the available dry-bone studies limited further interpretation. Important factors such as age, sex, body mass index, occupation, footwear, physical activity, systemic disease, osteoarthritis, foot posture, heel pain, and tendoachilles symptoms could not be assessed. Consequently, the independent contribution of talar facet morphology to spur formation could not be isolated from other potential determinants.

Relevance of plantar and non-plantar spur distinction: A strength of several included studies was that they separated plantar spurs from dorsal, posterior, tendoachilles-related, or combined spurs.[24-28] This distinction is important because plantar and posterior calcaneal spurs differ anatomically and may not share identical mechanisms of formation. Plantar spurs are typically discussed in relation to the plantar fascia, intrinsic plantar soft tissues, and plantar heel loading, whereas posterior or tendoachilles-related spurs are related to the region of the Achilles tendon insertion.

The present review therefore avoided treating all reported bony outgrowths as anatomically identical. Where studies reported plantar, dorsal, posterior, tendoachilles-related, combined, sustentaculum tali, enthesophyte, or bony spicule findings separately, the original terminology was preserved. Where studies reported calcaneal spurs collectively, their findings were interpreted as evidence relating to calcaneal spur formation overall rather than to a specific spur location.

This distinction is particularly relevant for future research. Studies that combine plantar and posterior spurs without separate reporting may obscure location-specific relationships between facet morphology and spur formation. A facet configuration associated with plantar enthesophyte formation may not necessarily have the same relationship with posterior or tendoachilles-related spur formation.

Relationship with clinical symptoms: The present review focused on anatomical association rather than clinical symptomatology. This distinction is important because calcaneal spurs, particularly plantar calcaneal spurs, are often discussed in relation to plantar heel pain and plantar fasciopathy, but their clinical significance remains debated. Spurs may be detected in both symptomatic and asymptomatic individuals, and their presence alone does not establish the cause of pain.[2,6,7]

Most included studies were dry-bone anatomical studies and did not contain information regarding symptoms, clinical history, imaging findings during life, or functional status. Therefore, no conclusions could be drawn regarding whether talar facet morphology was associated with symptomatic heel pain, whether spur-bearing calcanei were painful during life, or whether particular facet types influenced the likelihood that a spur became symptomatic.

Future studies should distinguish three related but separate questions: whether talar facet morphology is associated with calcaneal spur formation, whether calcaneal spur formation is associated with heel pain or tendoachilles-related symptoms, and whether facet morphology modifies the relationship between spur presence and clinical symptoms.

Comparison with previous literature: The findings of this review are consistent with previous anatomical observations showing that fused or continuous anterior-middle talar facet morphology is common in Indian skeletal samples and that calcaneal spurs are frequently reported in this group.[16,24-28] Kullar et al., Rajkohila et al., Kori et al., Biswal et al., and Vaishnav et al. all reported concentration of spur-bearing calcanei in Type I morphology.[24-28] Agarwal et al. reported a statistically significant association between calcaneal spur presence and articular facet configuration.[16]

However, the present review adds an important interpretive caution. The predominance of spurs in Type I calcanei should not be interpreted without considering the predominance of Type I morphology in the background sample. A descriptive concentration of spurs in a common morphology is not equivalent to proof of increased proportional risk. This distinction is important because many available anatomical studies were not designed to determine independent predictors of spur formation.

The findings also align with broader literature suggesting that calcaneal spur formation cannot be explained by a single mechanism. Kirkpatrick et al. reviewed anatomical, histological, and clinical evidence and emphasized the complex nature of plantar calcaneal spur formation.[1] Menz et al. challenged a purely traction-based explanation and emphasized the possible role of vertical compression.[2] The present review extends this discussion by suggesting that talar articular facet morphology may be relevant to the anatomical context of spur formation, but remains insufficiently studied as an independent factor.

Strengths of the review: A major strength of this review was its focused anatomical question. Rather than broadly reviewing all causes of heel pain or all radiographic findings associated with plantar fasciopathy, this review specifically examined calcaneal talar articular facet morphology in relation to calcaneal spur formation. This provided a clear anatomical framework for evidence synthesis.

A second strength was the cautious handling of spur terminology. Plantar, dorsal, posterior, tendoachilles-related, combined, sustentaculum tali, enthesophyte, and bony spicule findings were not treated as interchangeable unless the original study clearly supported such interpretation. This approach reduced the risk of misclassifying anatomically distinct bony outgrowths.

A third strength was the emphasis on denominator-based interpretation. Since Type I morphology was frequently the most common calcaneal configuration, the review avoided concluding that Type I morphology was an independent risk factor solely because many spur-bearing calcanei belonged to this group. This distinction strengthened the validity of the narrative synthesis and reduced the risk of overstating the evidence.

Limitations

This review had several limitations. First, the available evidence was derived mainly from dry-bone anatomical studies. Although such studies are valuable for describing skeletal morphology, they usually lack donor-level information on age, sex, body mass index, occupation, physical activity, footwear, systemic illness, inflammatory disease, diabetes, osteoarthritis, heel pain, tendoachilles symptoms, and lifetime loading history. These factors are potentially relevant to calcaneal spur formation but could not be evaluated.

Second, most studies used the calcaneus rather than the individual donor as the unit of observation. If both calcanei from the same donor were included in a skeletal collection, the observations may not have been fully independent. Because most studies did not provide donor-level pairing information, this issue could not be adjusted for.

Third, the included studies varied in their classification systems. Although Type I or Pattern I morphology was commonly described as fused or continuous anterior-middle talar facets, other categories differed across studies. Some studies used four-type systems, others used five-pattern classifications or additional subtypes. This limited direct comparison, particularly for less common facet configurations.

Fourth, spur reporting was heterogeneous. Some studies reported plantar, dorsal, posterior, tendoachilles-related, and combined spurs separately, whereas others reported overall calcaneal spurs or broader terms such as enthesophytes or bony spicules. This limited the ability to make consistent location-specific comparisons across all studies.

Fifth, reporting of morphology-specific denominator data was incomplete in some studies. Without the total number of calcanei with and without spurs in each facet category, it was difficult to determine whether spurs were proportionally more frequent within a given morphology or merely numerically concentrated there.

Sixth, the evidence base was geographically narrow. Most included studies were from Indian anatomical populations. This may limit generalizability to other populations, especially because talar facet morphology and calcaneal spur prevalence may vary according to ancestry, occupation, footwear habits, lifestyle, and skeletal collection characteristics.

Finally, causal inference was not possible. The included studies were cross-sectional anatomical observations. They could identify coexistence between facet morphology and spur formation, but they could not determine whether facet morphology preceded spur development, whether spur formation was influenced by lifetime mechanical loading, or whether both reflected shared degenerative or biomechanical processes.

Implications for future research: Future studies should use standardized and clearly illustrated classifications of calcaneal talar articular facet morphology. Authors should report the total number of calcanei in each facet type and the number with and without plantar, posterior, dorsal, tendoachilles-related, sustentaculum tali, and combined spurs separately. Such reporting would allow more reliable comparison across studies and may permit future quantitative synthesis.

Clinical imaging studies are also needed. Weight-bearing radiography, computed tomography, weight-bearing computed tomography, and magnetic resonance imaging could be used to evaluate talar facet morphology in living adults while also recording age, sex, body mass index, foot posture, plantar fascia thickness, heel-pad thickness, occupational loading, physical activity, diabetes, inflammatory disease, osteoarthritis, heel pain, and tendoachilles symptoms. Such studies would help clarify whether anatomical morphology is independently associated with spur formation after adjustment for relevant clinical and biomechanical factors.

Future research should also distinguish anatomical spur formation from symptomatic disease. The presence of a calcaneal spur should be analyzed separately from plantar heel pain or posterior heel pain because spur formation and symptoms are related but not identical phenomena. This distinction would improve both anatomical interpretation and clinical relevance.

CONCLUSION

Available anatomical evidence suggested that calcaneal spurs were frequently observed in calcanei with fused or continuous anterior-middle talar articular facets. However, Type I or Pattern I morphology was also the most common background calcaneal configuration in many included studies, limiting the strength of inference. Current evidence supported a possible anatomical and biomechanical relationship between calcaneal talar articular facet morphology and calcaneal spur formation, but did not establish Type I morphology as an independent predictor. More standardized anatomical studies and clinically characterized imaging studies are required to clarify this association.

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