

Radiological Characteristics and Anatomical Risk Factors in the Evaluation of Hallux Valgus in Chinese Adults

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Abstract

Background: There are no unified theories as to the anatomical changes that occur with hallux valgus, we investigated the radiological characteristics and anatomical risk factors for hallux valgus deformity in Chinese adults.

Methods: We reviewed 141 patients with hallux valgus (206 feet; 15 males, 126 females; mean age, 58.5 years). These patients attended Peking University People's Hospital from April 2008 to March 2014. All feet had intact radiological data, obtained using the Centricity RIS/PACS system. We measured hallux valgus angle (HVA), 1–2 intermetatarsal angle (IMA), proximal articular set angle (PASA), distal articular set angle, hallux interphalangeal angle, metatarsocuneiform angle, size of the medial eminence of the distal first metatarsal, tibial sesamoid position, and joint congruity of the first metatarsophalangeal joint (MTPJ).

Results: We found positive correlations between the HVA and IMA ($r = 0.279$, $P < 0.01$) and HVA and PASA ($r = 0.358$, $P < 0.01$), but not for IMA and PASA ($P > 0.05$). Feet were divided into three groups based on HVA severity. IMA ($P < 0.05$) and PASA ($P < 0.05$) in the mild group were significantly lower than that in the moderate and severe groups, with no significant difference determined for IMA or PASA between the moderate and severe groups ($P > 0.05$). Feet were then grouped based on the shape of the first metatarsal head. Using this grouping, HVA was significant higher in the rounded shape (19.92°) than in a flat shape (17.66°). The size of the medial eminence of the distal first metatarsal was positively correlated with HVA ($r = 0.185$, $P < 0.01$). The medial eminence in the moderate and severe groups was significantly larger than that in the mild group; moderate and severe groups were not significantly different.

Conclusions: PASA enlargement is an adaptive change during early hallux valgus formation, and decompensation leads to subdislocation in the first MTPJ. A rounded first metatarsal head would thus predispose a foot to hallux valgus. Furthermore, bone proliferation at the medial eminence may also lead to early hallux valgus development.

Key words: Hallux Valgus; Medial Eminence; Hallux Valgus Angle; Intermetatarsal Angle; Proximal Articular Set Angle; Subdislocation

INTRODUCTION

Hallux valgus is the most common deformity observed in ankle-foot surgery in adults, characterized by lateral deviation of the great toe, often erroneously described as an enlargement of bone or tissue around the joint at the head of the big toe. Hallux valgus is always accompanied by internal deviation of the first metatarsal, which is debated as the primary pathological change in the development of hallux valgus. A meta-analysis has indicated that the incidence of hallux valgus is 23% in the general population, and in older patients this could be as high as 35.7%.^[1] Hao-Tian *et al.*^[2] investigated 1233 adults and reported the mean incidence of hallux valgus at

7.95% in the general population. The ratio of men-to-women is 1:8.53, with 1.29% of all men, and 11% of women presenting with this deformity. The predisposing causes of hallux valgus are still unclear, but it is generally agreed to be associated with several factors such as career,^[3–5] shoes wearing,^[6–9] inheritance^[3,10] and local anatomical abnormalities. In addition to lateral deviation of the great toe, hallux valgus can also induce various pathological changes to the first ray of bones in the foot, such as internal deviation of the first metatarsal, metastatic metatarsalgia or bunion formation. If these changes are not identified when treating hallux valgus, they can affect the certainty of the outcome. However, there are still no unified theories as to the anatomical changes that occur with hallux valgus, some of which include changes to the proximal articular set angle (PASA), proliferation of the medial osteophytes of the first metatarsophalangeal joint (MTPJ), among others.

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The related clinical references for hallux valgus are mostly from western population, with clinical studies rare among the Chinese population. We, therefore, investigated the radiological characteristics of hallux valgus in the Chinese population and evaluated the anatomical risk factors associated with its presence.

METHODS

General data

The inclusion criteria were as follows: Age >18 years; a hallux valgus angle (HVA) of > 20° and the presence of hallux valgus deformity or bunion in appearance; no previous history of hallux valgus surgery, including osteophyctectomy; and intact imaging data for weight-bearing AP radiographs of the foot taken in our department. Patients were excluded if they did not meet any of these criteria. Finally, we included 141 hallux valgus patients (206 feet) who visited our department from April 2008 to March 2014. Among these patients, there were 15 males and 126 females. Sixty-five patients suffered from the bilateral deformity whereas 102 feet were left, another 104 feet were right. The mean age was 58.5 years (range, 25–80 years).

Evaluation methods

All imaging measurements were performed by three doctors (Jin KJ, Ma MT and Liu ZD), and all surveyors received training before measurements were taken to ensure uniformity of the results. We used the Centricity

RIS/PACS CE software (GE, USA) to gauge the HVA, the 1–2 intermetatarsal angle (IMA), PASA, distal articular set angle (DASA), hallux interphalangeal angle (IPA), and the metatarsocuneiform angle (MCA). We also gauged the depth of the medial osteophyte of the first MTPJ and evaluated joint congruity of the MTPJ, recorded the shape of the first metatarsal head, and the determined the tibial sesamoid position (TSP).

Parameters and gauge methods

Weight-bearing foot AP views were taken with the patient standing on a board with their knee straight, and projecting a light beam 15°s to the vertical line. In this position, the focus lies on the base of the third metatarsal, but the forefoot and middle foot can also be well-viewed. This also facilitates viewing of the gouge.

Hallux valgus angle

The HVA is formed by the longitudinal axis of the first metatarsal and the longitudinal axis of the proximal phalanx [Figure 1a]. The longitudinal axis of the first metatarsal connects the middle point of the medial and lateral cortices of the proximal and distal first metatarsals. The longitudinal axis of the proximal phalanx is similarly drawn. Normally, the HVA is no more than 15°, and when increased, it typifies a hallux valgus deformity.

Intermetatarsophalangeal angle

The IMA is the angle between the extension longitudinal axis of the first and second metatarsals. The longitudinal axis of

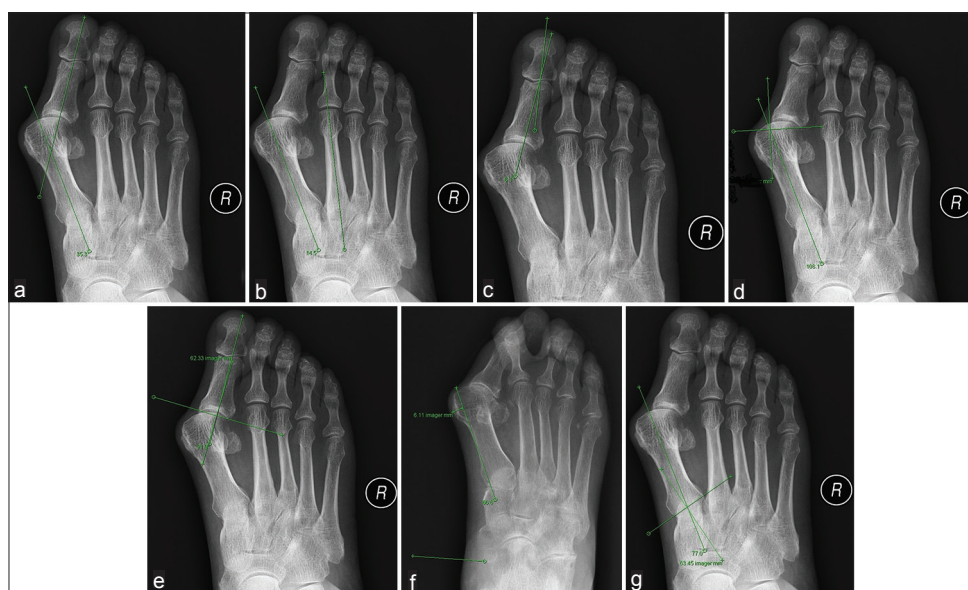


Figure 1: The hallux valgus angle is formed by the longitudinal axis of the first metatarsal and the longitudinal axis of the proximal phalanx (a). The intermetatarsal angle is the angle between the extension longitudinal axis of the first and second metatarsals (b). The interphalangeal angle is the angle between the longitudinal axis of the proximal phalanx and the longitudinal axis of the distal phalanx (c). The proximal articular set angle (PASA) is determined as follows: first, a line is drawn between the medial and lateral points of the articular surface. This is followed by drawing a vertical line through the center. This line and the longitudinal axis of the first metatarsal form the PASA (d). The distal articular set angle defines the relationship of the proximal articular surface of the proximal phalanx to the longitudinal axis of the proximal phalanx (e). The medial eminence is measured by drawing a line along the medial diaphyseal border of the first metatarsal. A perpendicular line is then drawn at the widest extent of the medial eminence (f). Metatarsocuneiform angle is formed by the intersection of the longitudinal axes of the first metatarsals and the proximal articular surface of the first metatarsal. Image is a weight-bearing AP view of the foot (g).

the first metatarsal is formed by drawing a line connecting the middle points of the medial and lateral cortices of the proximal and distal first metatarsals. The longitudinal axis of the second metatarsal is created similarly [Figure 1b].

Interphalangeal angle

The IPA is the angle between the longitudinal axis of the proximal phalange and the longitudinal axis of the distal phalange [Figure 1c].

Proximal articular set angle

The PASA is the included angle formed by the articular surface of the distal first metatarsal and the longitudinal axis of the first metatarsal. To measure this angle, we first draw a line between the medial and lateral points of the articular surfaces, and then a vertical line is drawn. This line and the longitudinal axis of the first metatarsal form the PASA [Figure 1d].

Distal articular set angle

On an AP weight-bearing radiograph, the DASA defines the relationship of the proximal articular surface of the proximal phalange to the longitudinal axis of the proximal phalange [Figure 1e]. Normally, the DASA is no more than 7.5° .

Medial eminence

One of the key components of a hallux valgus deformity is the size of the medial eminence. It is frequently the prominence that is the focus of pain and footwear intolerance by patients. The size of the medial eminence is measured by drawing a line along the medial diaphyseal border of the first metatarsal. A perpendicular line is then drawn at the widest extent of the medial eminence and measured [Figure 1f].

First metatarsocuneiform joint angle

On an AP radiograph, the MCA is formed by the intersection of the longitudinal axis of the first metatarsal and the proximal articular surface of the first metatarsal [Figure 1g].

Observation items

We believe that the shape of the distal articular surface of the first metatarsal plays a role in the formation and development of hallux valgus. Based on this assumption, we ascertain the shape as flat [Figure 2a] or rounded [Figure 2b], and split the



Figure 2: The shape of the distal articular surface of the first metatarsal. Image is a weight-bearing AP view of the foot. (a) Flat; (b) Rounded.

findings based on these two groups to calculate the relationship between the shape of the first metatarsal and the HVA.

Tibial sesamoid position

Traditionally, based on its relationship with the central axis of the first metatarsal, some authors recommend a 7° classification system to evaluate the TSP. However, we believe this classification to be not well-comprehended and so we simplified it to 4° , as follows: (I) The sesamoid stays *in situ* or not beyond 25% of the central axis of the first metatarsal [Figure 3a]. (II) The sesamoid deviates laterally beyond 25%–75% of the central axis of the first metatarsal [Figure 3b]. (III) The sesamoid deviates laterally beyond 75% of the central axis of the first metatarsal but not beyond 25% of the fibular border of the first metatarsal [Figure 3c]. (IV) The sesamoid deviates laterally beyond 25% or more of the fibular border of the first metatarsal [Figure 3d].

Statistical analysis

Data analysis was performed with SPSS version 20.0 (SPSS IBM Chicago, IL, USA). We verified the correlation of HVA and IMA, HVA and PASA, HVA and IPA, HVA and DASA, HVA and MAC using a correlation analysis (Pearson's R correlation coefficient). We divided patients into groups according to HVA and performed an analysis of variance (ANOVA). The group comparison was performed with the least significant difference (LSD) t -test. Groups were divided according to the shape of the first metatarsal head; then HVA was used to compare among the samples using an independent samples t -test. An independent samples t -test was used to compare the differences in the PASA between the groups of subdislocation and normal alignment of first MTPJ. All differences were considered significant with a $P < 0.05$.

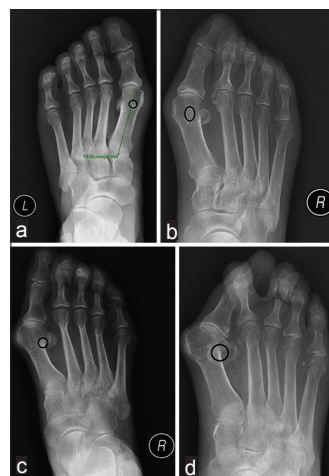


Figure 3: Classification of the tibial sesamoid position (TSP). (a) The sesamoid stays *in situ* or not beyond 25% of the central axis of the first metatarsal. (b) The sesamoid is deviated laterally beyond 25%–75% of the central axis of the first metatarsal [Figure 9b]. (c) The sesamoid is deviated laterally beyond 75% of the central axis of the first metatarsal but not beyond 25% of the fibular border of the first metatarsal. (d) The sesamoid is deviated laterally beyond 25% or more of the fibular border of the first metatarsal. Images are of a weight-bearing AP view of the foot.

RESULTS

General data analysis

We included 141 patients (206 feet) patients that met the inclusion criteria. Feet were divided according to the severity of HVA or in terms of the presence of subdislocation. For HVA severity, 73 feet were determined to be in the mild group ($HVA < 30^\circ$) (Group 1), 81 feet in the moderate group ($30^\circ < HVA < 40^\circ$) (Group 2), and 52 feet in the severe group ($HVA > 40^\circ$) (Group 3). For the presence of subdislocation of the first MTPJ, 99 feet were subdislocated whereas 107 feet were assumed normal [Table 1]. In terms of each of the HVA severity groups, normal versus subdislocation were as follows: Mild group, 62 feet versus 11 feet, respectively; moderate group, 37 feet versus 44 feet, respectively; severe group, 8 feet and 44 feet, respectively.

Correlation analysis of hallux valgus angle and hallux valgus angle, proximal articular set angle, distal articular set angle, and metatarsocuneiform angle

We performed a correlation analysis with a Pearson correlation coefficient to ascertain relationships among the various tested parameters. The results showed that HVA and PASA were positively correlated ($r = 0.358$, $P < 0.01$), as were HVA and IMA ($r = 0.279$, $P < 0.01$). HVA showed a relatively higher correlation with PASA than IMA. IMA had no significant correlation with PASA ($r = 0.086$, $P > 0.05$). Besides, there was no significant correlation between HVA and MCA ($r = -0.133$, $P > 0.05$) or between HVA and DASA ($r = -0.094$, $P > 0.05$).

Comparison of proximal articular set angle and hallux valgus angle between different severities of hallux valgus

All feet were divided into three groups according to HVA severity as indicated above. In the mild group, the mean PASA was $14.89 \pm 1.14^\circ$ and the mean IMA was $11.12 \pm 0.69^\circ$. In the moderate group, the mean PASA was $20.66 \pm 1.45^\circ$ and the mean IMA was $12.53 \pm 0.81^\circ$. In the severe group, the mean PASA was $21.12 \pm 1.78^\circ$ and the mean IMA was $13.60 \pm 0.98^\circ$. The one-way ANOVA suggested that there was a significant difference between different groups for the PASA ($P < 0.01$) and IMA ($P < 0.01$) [Table 2a]. Further group comparisons were performed with LSD *t*-test, which showed differences among the mild group and moderate group, and between mild group and severe group for both PASA ($P < 0.05$) and IMA ($P < 0.05$). However, there were no significant differences between moderate and severe groups for PASA ($P = 0.642$) and IMA ($P = 0.095$) [Table 2b].

Relationship of proximal articular set angle and alignment of the first metatarsophalangeal joint

Theoretically, a larger PASA would indicate a better likelihood of the first MTPJ retaining normal alignment. However, we found that the mean PASA value in the normal alignment group was $17.66 \pm 1.21^\circ$, whereas the mean PASA in the subdislocation group was significantly higher at $19.92 \pm 1.47^\circ$ ($P < 0.05$; Table 3).

Tibial sesamoid position in different severity of hallux valgus [Table 4a]

The tibial sesamoid was absent in 1 foot. In the other 205 feet, a dislocated tibial sesamoid (II° or higher) accounted for more than 94% of the feet analyzed. We split those that were degrees I and II

Table 1: General data of included patients

Age (years)	58.5 (25 – 80)
Gender (n)	
Male	15
Female	126
Side (n)	
Left	102
Right	104
Alignment of MTPJ (n)	
Normal	107
Subdislocation	99

MTPJ: Metatarsophalangeal joint.

Table 2a: Comparison of IMA and PASA among groups with one-way ANOVA

Group	n	Mean ($^\circ$)	F	P
IMA				
1	73	11.12	7.555	0.001
2	81	12.53		
3	52	13.60		
Total	206	12.30		
PASA				
1	73	14.89	21.767	0.000
2	81	20.66		
3	52	21.18		
Total	206	18.75		

IMA: Intermetatarsal angle; PASA: Proximal articular set angle; ANOVA: Analysis of variance.

Table 2b: Post-hoc analysis: Multiple comparisons of IMA and PASA among the three groups (LSD *t*-test)

Group	Mean difference	P
IMA		
1		
2	-1.41319	0.016
3	-2.48548	0.000
2		
1	1.41319	0.016
3	-1.07229	0.094
3		
1	2.48548	0.000
2	1.07229	0.094
PASA		
1		
2	-5.76885	0.000
3	-6.28459	0.000
2		
1	5.76885	0.000
3	-0.51574	0.642

IMA: Intermetatarsal angle; PASA: Proximal articular set angle; LSD: Least significant difference.

Table 3: Comparison of PASA between normal and sub dislocation of the first MTPJ

Alignment	<i>n</i>	Mean (°)	<i>t</i>	<i>P</i>
Normal	107	17.66 ± 1.21	-2.396	0.017
Subdislocation	99	19.92 ± 1.47		

PASA: Proximal articular set angle; MTPJ: Metatarsophalangeal joint.

Table 4a: Tibial sesamoid position in groups according to the 4° classification system (*n*)

Group	1	2	3	4	Absence	Total
Mild	6	29	32	6	0	73
Moderate	3	39	34	3	1	81
Severe	3	14	26	8	0	52

Table 4b: Comparison of HVA between mild and severe groups

TSP	HVA (°)	<i>t</i>	<i>P</i>
Mild (I, II)	32.68 ± 7.38	-2.147	0.033
Severe (III, IV)	35.18 ± 8.83		

TSP: Tibial sesamoid position; HVA: Hallux valgus angle.

into a mild group, and those that were degrees III and IV into a severe group. The mean HVA in the mild group was $32.68 \pm 7.38^\circ$ and in the severe group was $35.18 \pm 8.83^\circ$, which was significantly higher ($P < 0.05$; Table 4b).

Hallux valgus angle and shape of first metatarsal head

We found that 90 feet had a flat metatarsal head, with a mean HVA of $32.26 \pm 1.51^\circ$, whereas 116 feet had a rounded metatarsal head, with a mean HVA of $35.59 \pm 1.50^\circ$. The difference between the two groups was statistically significant ($P < 0.01$; Table 5).

Hallux valgus angle and medial eminence of distal first metatarsal

A correlation analysis was performed using the Pearson correlation coefficient, which showed a positive correlation between HVA and the medial eminence of the distal first metatarsal ($r = 0.185$, $P < 0.01$). Groups were divided according to HVA severity as previously described. The mean depth of the medial eminence was 4.36 ± 0.26 mm in the mild group, 4.71 ± 0.27 mm in the moderate group, and 4.80 ± 0.24 mm in the severe group. Analysis using a one-way ANOVA indicated significant differences between the mild and moderate groups, and so is mild and severe groups ($P < 0.05$; Table 6a). A multiple comparison with an LSD *t*-test showed a significant difference between the mild and moderate groups ($P < 0.05$), but no significant difference between the moderate and severe groups ($P = 0.632$) [Table 6b].

DISCUSSION

The purpose of the hallux valgus classification is to guide clinical treatment. There are numerous ways to classify

Table 5: Comparison of HVA for flat versus rounded first metatarsal heads

Shape	<i>n</i>	HVA (°)	<i>t</i>	<i>P</i>
Flat	90	32.26 ± 1.51	-2.907	0.004
Rounded	116	35.59 ± 1.50		

HVA: Hallux valgus angle.

Table 6a: Comparison of the medial eminence among different HVA groups

Group	<i>n</i>	Mean value (mm)	<i>F</i>	<i>P</i>
1	73	4.36 ± 0.26	3.078	0.048
2	81	4.71 ± 0.27		
3	52	4.80 ± 0.24		
Total	206	4.61		

HVA: Hallux valgus angle.

Table 6b: Post-hoc analysis: Comparison of the medial eminence among different HVA groups (LSD *t*-test)

Group	Mean difference	<i>P</i>
1		
2	-0.35273	0.048
3	-0.44645	0.026
2		
1	0.35273	0.048
3	-0.09372	0.632
3		
1	0.44645	0.026
2	0.09372	0.632

HVA: Hallux valgus angle; LSD: Least significant difference.

hallux valgus, which are based on a variety of methods, and none of these are widely accepted. Mann and Coughlin^[11] divided hallux valgus into three stages based on HVA, IMA, and TSP. However, we found that although there were some correlations between HVA and IMA ($r = 0.277$, $P < 0.05$) and between HVA and TSP, these were not strictly parallel. In our patients, there was no significant difference in IMA between the HVA $> 30^\circ$ group and HVA $> 40^\circ$ group, or for the TSP values. In China, Gui *et al.*^[12] classified hallux valgus by the value of HVA and PASA but they neglected to incorporate some pathological patterns, such as IPA enlargement hallux valgus, and their classification, therefore, lacks a relative quantitative index. Therefore, we still need more research to establish a classification for Chinese patients with hallux valgus.

There are various pathological changes throughout the different stages of hallux valgus, such as internal deviation of first metatarsal and lateral deviation of the sesamoid bone. Foreign research literature generally considers that IMA increases in accordance with hallux valgus progression and that the two values show a significant linear relationship ($r = 0.71$).^[5,13-16] However, our results revealed that although the two values show a linear relationship to a certain extent ($r = 0.277$), this value is obviously lower than that determined for foreign research. When comparing

among the groups, we found differences between the mild and moderate groups, but no difference between the moderate and severe groups; indeed, even the IMA in the severe group was higher than that of the moderate group (13.60 vs. 12.53). In comparison, PASA had a higher relation with HVA ($P = 0.366$), but these same differences among the groups were determined, with differences only found between the mild and moderate groups. There is currently no agreement in the literature as to the cause of hallux valgus and the medial deviation observed for the first metatarsal; but, based on the low correlation between HVA and IMA, we found that in Chinese adults, hallux valgus was caused by medial deviation of the first metatarsal in only a few patients.

Proximal articular set angle is another risk factor of hallux valgus. PASA could allow for the normal alignment of the first MTPJ when the proximal phalange deviates laterally, but only within a certain angle (no more than 15°). Foreign literature has reported the normal PASA range as $16.3\text{--}18^\circ$,^[17-22] whereas, in China, Gui *et al.* reported a much lower mean PASA of 15.72° .^[12] PASA values for hallux valgus are also different between China and Abroad,^[23] with foreign reports indicating 10° . By comparison, Gui *et al.* reported PASA at 15.72° in normal alignment and 18.54° in subdislocation of the first MTPJ.^[12] PASA increments could induce static hallux valgus, and this deformity would get worse with increments in PASA. Piggott suggested that hallux valgus induced by increments in PASA could lead to pain but that the deformity rarely worsens. However, our results were different, showing a relative correlation between PASA and HVA ($r = 0.366$), and differences between the mild and moderate groups ($P < 0.05$), but no difference between the moderate and severe groups. These results suggested that the PASA maybe a compensatory pathology in the development of hallux valgus, for which a certain range in PASA values could maintain the alignment of the first MTPJ. Besides, we found the PASA in the subdislocation group to be larger than that in the normal group (19.22 vs. 17.66), indicating that the PASA must be within a certain range of degrees to maintain the alignment of the first MTPJ. When hallux valgus continues to get worse and beyond this compensation, the first MTPJ would dislocate. Thus, when surgeons are deciding on a strategy to treat hallux valgus, they should pay attention to the degree of PASA: If too large, a normal alignment may lead to a dislocation at the MTPJ, and if an osteotomy of the base of the first metatarsal is performed, this may lead to increased pain postoperatively.

The shape of the head of the first metatarsal is considered as another risk factor of hallux valgus.^[11,24] We split the cohort into two types according to the aspect of the head of the first metatarsal: Flat and rounded. A flat head is generally considered more stable, as it can resist stress to deviate the phalange laterally,^[25] whereas a rounded head is regarded as relatively unstable, and could be a risk factor for hallux valgus. When Schweitzer^[26] compared the shape of the first metatarsal of hallux valgus and hallux rigidus,

he concluded that there was no difference between these feet. Our results, however, suggest that the mean HVA was higher in the rounded group than in the flat group. Despite this apparent association, however, there are still no strict criteria to evaluate the shape of the metatarsal head. We must emphasize that we estimated the shape of the head of the first metatarsal on X-rays, which is subjective, and thus the accuracy of this assessment might be in doubt.

Resection of the medial eminence of the distal metatarsal is the standard procedure for treating hallux valgus. However, it is still debated whether the medial eminence is the result of skeletal proliferation after hallux valgus or a component of the distal first metatarsal. Haines and McDougall,^[27] and Lane^[28] all considered the medial eminence to be a component of the distal first metatarsal instead of skeletal proliferation, and that it becomes conspicuous simply because when the surface of first MTPJ decreases, the sagittal groove deviates laterally, and this leads to increased exposure of the medial eminence. The sagittal groove then forms the boundary of the medial eminence and the articular surface. Thordarson and Krewer^[29] performed a series of foot measurements and concluded that there was no difference in the depth of the medial eminence between hallux valgus and normal feet. Meanwhile, Volkmann^[30] and Truslow^[31] both suggested that there is skeletal formation in the development of hallux valgus. We measured the medial eminence depth in patients with hallux valgus and found that the depth of the medial eminence in the moderate group was significantly larger than that in the mild group. From these results, we speculate that there might be a certain degree of bone formation during the early stages of hallux valgus development, but that, when the deformity advances, this rate of bone formation may slow down or become static. Besides, when we measured the medial eminence, we found that most of the prolonged line of the medial cortex of the first metatarsal was in the medial side of the sagittal groove. This suggested that if the surgeon always takes the sagittal groove as a landmark during medial eminence resection, there might be a risk of over-resection to some extent. We must again emphasize that all of our measurements were performed using plain X-ray; using a PACS system, one could avoid interference factors like magnification to improve the accuracy of these measurements during surgery.

Lateral deviation of sesamoid bones is also a typical pathological alteration in hallux valgus. Stephens^[32] considered that, in early hallux valgus, the medial capsule of the first MTPJ becomes lax, and the bone crest between the medial and lateral articular surfaces of the metatarsal head is subjected to wearing. When the proximal phalange deviates laterally, this would cause a stretch to the sesamoid within the intermetatarsosesamoid ligaments, and when the first metatarsal deviates medially, the sesamoid would deviate laterally, with no bone crest protection. Sesamoid position is generally evaluated by TSP. Hardy and Clapham^[13] divided TSP into 7° using its relationship with the central axis of the first metatarsal. They observed 252 feet of hallux valgus and

174 normal feet, and found that, in normal feet, over 90% of tibial sesamoid bones lay within 3° or less, whereas, in hallux valgus, 88% or more tibial sesamoid bones lay within 4°. We also evaluated the sesamoid position with respect to its relationship with the central axis of the first metatarsal, but we just divided TSP into 4°. Our second degree (II) was fairly equivalent to degree IV of Hardy's classification. Based on our classification, we found that over 94% of feet from patients with hallux valgus were classified as degree II. When we regarded degrees I and II as mild group, and degrees III and IV as severe, we found that the HVA in the severe group was significantly higher than that in the mild group (35.18° vs. 32.68°), which supported the findings of Gui^[33] also in a Chinese population.

There are various pathological patterns of hallux valgus, and the etiology arises from not only anatomical factors, but also inheritance, shoe wearing, and career, among other factors. Besides removing the predisposing factors, we should also pay more attention to the pathological characteristics of the disorder when deciding on a treatment. Further research on the etiology and pathological patterns of hallux valgus is still required to promote the further development of its clinical treatment.

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