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Pictorial review: Foot axes and angles

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Abstract

Using radiographs and diagrams, this article reviews the most commonly used axes and angles of the foot, including: longitudinal axis of the rearfoot, collum tali axis, talocalcaneal angle, cuboid abduction angle, longitudinal axis of the lesser tarsus, lesser tarsus angle, talonavicular angle, longitudinal axis of the metatarsus, forefoot adductus angle, metatarsus adductus angle, first intermetatarsal angle, hallux valgus angle, proximal and distal articular set angles, and hallux interphalangeal angle, plane of support, collum tali axis, talar declination angle, calcaneal inclination angle, lateral talocalcaneal angle, first metatarsal declination axis and calcaneal inclination angle.

Standard radiographs for evaluation of foot deformities include dorsoplantar (anteroposterior), medial oblique and lateral projections. The angles and axes are measured on the dorsoplantar and lateral weight bearing radiographs obtained in the angle and base of gait to provide an accurate representation of the foot in its functional position [1]. These measurements are for the adult and not the developing skeleton.

Axes and angles on the dorsoplantar projection

Longitudinal axis of the rearfoot (LARF)

The LARF is a line parallel to the distal portion of the lateral border of the calcaneus. In the normal foot it is parallel to the axis of the fourth metatarsal bone (Figure 1).

Collum tali axis (CTA)

The CTA is a line bisecting the head and neck of the talus (Figure 1). Normally this line extends through the center of the first metatarsal head. In the pronated foot, it passes medial to the first metatarsal head. In the supinated foot the CTA runs lateral to the first metatarsal head.

Talocalcaneal angle (TCA)

The TCA is the angle between the collum tali axis and the longitudinal axis of the rear foot (Figure 1) (normal: 17°–21°). The talocalcaneal angle increases with pronation and decreases with supination.

Cuboid abduction angle (CAA)

The CAA is the angle between the longitudinal axis of the rearfoot and a line tangential to the lateral surface of the cuboid (Figure 2) (normal: 0°–5°). This angle increases above 5° with pronation of the mid-tarsal joint and decreases below 0° with supination and adduction.

Longitudinal axis of the lesser tarsus (LALT)

The LALT is a line perpendicular to the line AB that transects the lesser tarsus (Figure 3). A is one-half the distance between the medial aspect of the talonavicular joint and the medial aspect of the first tarsometatarsal joint; B is one-half the distance between the lateral aspect of the calcaneocuboid joint and the lateral aspect of the fifth tarsometatarsal joint.

Lesser tarsus angle (LTA)

The LTA is the angle between the longitudinal axis of the lesser tarsus and the longitudinal axis of the rear footprint (Figure 3). This angle increases with pronation and decreases with supination.

Talonavicular angle (TNA)

The TNA is the angle between the collum tali axis and the bisection of the lesser tarsus (Figure 4) (normal: 60°–80°). This angle is greater than 80° in the supinated foot, and less than 60° in the pronated foot.

Longitudinal axis of the metatarsus (LAM)

The LAM is a line bisecting the neck and the proximal portion of the diaphysis of the second metatarsal bone (Figure 5).

Forefoot adductus angle (FAA)

The FAA is the angle between the longitudinal axis of the metatarsus and the longitudinal axis of the rear foot (Figure 5) (normal: 4°–12°). This angle tends to decrease with pronation.
Metatarsus adductus angle (MAA)

The MAA is the angle between the longitudinal axis of the metatarsus and the longitudinal axis of the lesser tarsus (Figure 6) (normal < 15°). A foot with a normal MAA is a “rectus” foot; a foot with an increased MAA is an “adductus” foot. Medial deviation of the first metatarsal increases as the MAA increases.

First intermetatarsal angle (IMA)

The IMA or metatarsus primus adductus angle is the angle between longitudinal axis of the first and second metatarsal bones (Figure 7). Normal IMA is 8°-12° in a rectus foot and 8°-10° in an adductus foot. Abnormal IMA up to 15° can be corrected with distal osteotomies, while increases greater than 15° require proximal osteotomies [2].

Hallux valgus angle (HVA)

The hallux valgus or hallux abductus angle is formed by the longitudinal axis of the first proximal phalanx and the longitudinal axis of the first metatarsus [3-5] (Figure 8) (normal: 5°-15°). Hallux abductus valgus is mild when HVA is 16°-25°, moderate when HVA is 26°-35°, and severe when HVA is greater than 35°. In hallux varus or adductus the HVA is less than 0°.

Proximal and distal articular set angles (PASA and DASA)

The PASA is the angle between the perpendicular to the effective articular surface of the first metatarsal head and the longitudinal axis of the first metatarsal bone (Figure 9). The DASA is the angle between the perpendicular to the effective articular surface of the 1st proximal phalanx and the longitudinal axis of the 1st proximal phalanx (Figure 9) (normal PASA < 10°; normal DASA 0°-6°).

Hallux interphalangeal angle (HIA)

The HIA is the angle formed between the longitudinal axes of the proximal and distal phalanges of the hallux (Figure 10) (normal < 10°).

Axes and angles on the lateral projection

Plane of support (PS)

The PS is defined by the line connecting the most inferior point of the tuberosity of the calcaneus with the most inferior point of the fifth metatarsal head (Figure 11).

Collum tali axis (CTA)

The CTA bisects the head and neck of the talus (Figure 11).

Talar declination angle (TDA)

The TDA is the angle between the plane of support and the collum tali axis (Figure 11). Normal is approximately 21°. It should be the same as the first metatarsal declination angle.

Calcaneal inclination axis (CA)

The calcaneal inclination axis is the line connecting the most inferior point of the tuberosity of the calcaneus with the most distal and inferior point of the calcaneus along the calcaneocuboid joint (Figure 12).

Lateral talocalcaneal angle (LTCA)

The LTCA is formed by the calcaneal axis and the collum tali axis (Figure 12) (normal: 35°-50°).

First metatarsal declination axis (MDAx)

The MDAx is the line bisecting the neck and proximal shaft of the first metatarsal bone, and is normally parallel to the collum tali axis (Figure 13). In metatarsus primus elevatus, MDAx angles above the collum tali axis. A plantarflexed MDAx is present when MDAx angles below the collum tali axis. Metatarsus primus elevatus contributes to the development of hallux limitus and hallux rigidus.

First metatarsal declination angle (MDA)

The MDA is the angle between plane of support and the first metatarsal declination axis. Normal is approximately 21°. It should be the same as talar declination angle (Figure 13).

Calcaneal inclination angle (CIA)

The CIA is the angle between the plane of support and the calcaneal inclination axis (Figure 14) (normal 20°-30°). This angle is decreased in pes planus and increased in rearfoot cavus (Figure 15).

(Please turn over for figures.)
Figures 1–3. TCA, talocalcaneal angle; LARF, longitudinal axis of the rearfoot; CTA, collum tali axis; CAA, cuboid abduction angle; LTA, lesser tarsus angle; LALT, longitudinal axis of the lesser tarsus.

Figures 4–6. TNA, talonavicular angle; CTA, collum tali axis; AB, bisection of the lesser tarsus; FAA, forefoot adductus angle; LAM, longitudinal axis of the metatarsus; LARF, longitudinal axis of the rearfoot; MAA, metatarsus adductus angle; LALT, longitudinal axis of the lesser tarsus.
Figure 7. (a) IMA, first intermetatarsal angle; (b) normal IMA; (c) metatarsus primus varus IMA > 10°.

Figure 8. (a) HVA, hallux valgus angle; (b) normal HVA is 5°–15°; (c) severe hallux valgus HVA > 35°.
Figure 9. (a) Proximal and distal articular set angles (PASA and DASA); (b) normal PASA < 10°; (c) abnormal PASA > 10°.

Figure 10. (a) HIA, hallux interphalangeus angle; (b) normal, HIA = 9°; (c) hallux valgus interphalangeus, HIA = 21°.
Figure 11. TDA, talar declination angle; CTA, collum tali axis; PS, plane of support.

Figure 12. LTCA, lateral talocalcaneal angle; CA, calcaneal inclination axis; CTA, collum tali axis.

Figure 13. MDA, first metatarsal declination angle; PS, plane of support; MDAx, first metatarsal declination axis.

Figure 14. CIA, calcaneal inclination angle; PS, plane of support; CA, calcaneal inclination axis.
Figure 15. (a) Normal foot. (b) Pes planus: the axis of the talus is more vertical than normal, the talocalcaneal angle is greater than 50°. (c) Pes cavus: the axis of the talus is more horizontal than normal, the calcaneal inclination angle is greater than 40°.

References