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Association of ankle instability and foot deformity

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95 patients operated on for chronic lateral ankle instability were compared for possible foot deformities with 34 normal persons. All the feet underwent a standardized radiographic examination. Measurements of three defined angles on a lateral nonweight-bearing radiograph indicated higher foot arches in the instability group than in the control group. Benink's tarsal index showed a higher frequency of cavovarus deformities in the instability group.

Longitudinal high foot arches are reported to have a higher frequency in patients with lateral ankle ligament injuries (Dehne 1933, Bonnin 1950, Rubin and Witten 1960, Rose 1962, Rubin and Witten 1964, Benink 1985). Clinical evaluation of foot deformities can be difficult. With the aid of footprints, Le Lelièvre (1961) showed that a foot with a low longitudinal arch may leave the imprint of a hollow foot. Benink (1985) introduced a radiographic tarsal index for evaluating cavus and varus deformity.

We report a possible correlation between foot deformities and chronic lateral ankle instability.

Patients and methods

The probands comprised 95 of 100 prospective patients operated on for chronic lateral instability of the ankle. Preoperatively, standardized radiographs of both ankles were taken in all the patients. Only radiographs with a correctly positioned foot and ankle were included for comparison (95 patients). All the patients had had ankle instability for at least 5 months. The diagnosis was based on manual examination and stress radiographs with an increased talar tilting of 6° or more (Larsen 1988) and/or anterior rotational talar displacement with an index of more than 93 (Lindstrand and Mortensson 1977). The group consisted of 49 men and 46 women, average age 28 (16–61) years.

The control group comprised 34 randomly selected persons (13 men and 21 women) with an average age of 37 (16–64) years, who had had no previous ankle or foot trauma/complaints. In a few cases, a part of the foot was outside the radiographic film, so that some variables could not be measured or calculated.

A special device was used to obtain standardized radiographs without weight bearing (Figure 1). A

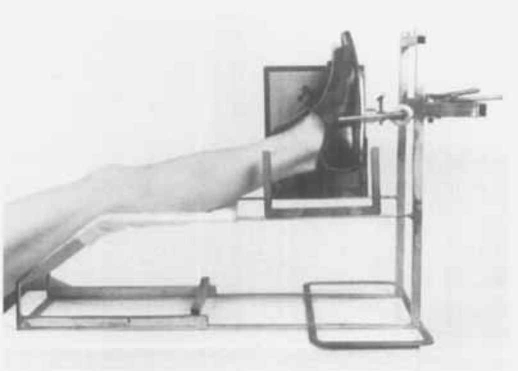

Figure 1. Apparatus used to standardize the radiographic examination.

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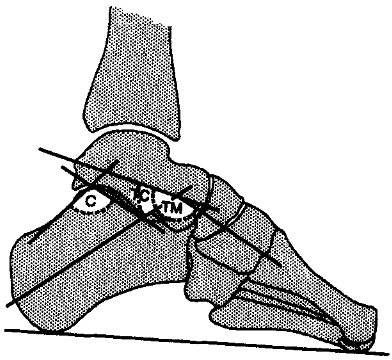

Figure 2. Angles TC, C, and TM. See text for details.

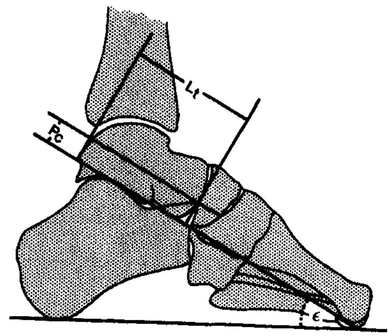

Figure 3. Measurements used to evaluate tarsal index (TI). See text for details.

film cassette was placed on one of the bars of the apparatus, and the distance between the x-ray tube and the object was 70 cm. The foot was fixed in an adjustable laced shoe with a soft leather front and a hard nonflexible heelcounter. The foot was positioned at 25° inward rotation and 10° plantar flexion. All the radiographs were taken in the lateral position with the central ray passing laterally-medially through the malleoli, giving concentric arches of the two joint surfaces of the talocrural joint. This position includes a good view of the subtalar joint.

The foot deformity was evaluated by standardized measurements on the radiographs (Figures 2 and 3). All the measurements were performed by the same examiner. TC represents the angle between a line through the posterior articular margin of the talar trochlea and the midpoint of the caput tali and the longitudinal line through the calcanean corpus. Feet with high angles have a high arch (Keim and Ritchie 1970). C represents the angle between lines through the posterior calcanean joint surface and the posterosuperior part of the calcanean body. A small angle is seen in feet with high arches (Gamble and Yale 1966). TM is the angle between a line through the posterior articular margin of the talar trochlea and the midpoint of the caput tali and a line through the midpoint of the base of the first metatarsal bone. Because the axis of the first metatarsal bone could be difficult to estimate, this modification of the angle proposed by Gould (1983) was used. A small angle implies a high arch of the foot.

The tarsal index (TI) was determined as follows (Benink 1985): the angle of inclination of the talocalcaneal joint (∈–tc) was determined by measuring the angle (∈) of the tangent to the visible posterior articular surface of the calcaneus and the visible anterior articular surface at the underside of the head of the talus. The front of the calcaneus overlaps the head of the talus, and the extent of the overlap (Pc) was measured. The tarsal index is thus given as TI = 100 x Pc/Lt x tg ∈–tc (Figure 3). A small tarsal index implies feet with high arches and/or varus position of the heel (Benink 1985).

Forty of the radiographs were blindly measured twice. The mean deviation of the angles TC, C, and TM were 0.36°, 1.5°, and 0.63°, respectively, and for the TI it was 2.7.

The variables were tested for normal distribution. Variation in the variable measurements between the two groups was estimated by the *F*-test, which in all the cases was not significant, and a nonpaired *t*-test was used for comparison between the two groups. Because the TI showed a sloped distribution curve, the Mann-Whitney test was used for analysis. A significance level of $P < 0.05$ was chosen.

Results

In neither group did the TC, C, and TM angles differ between the right and the left side. The tarsal index (TI) in right and left ankles differed slightly in both groups ($P = 0.012$ and $P = 0.030$, respectively); both ankles were therefore included in the calculations and comparisons.

The TC angle was higher and the TM angle was lower in probands than in controls (Table 1), indi-

Table 1. TC, C, and TM angles and tarsal indices for patients with chronic ankle instability and controls

		Patients			Controls			*P*-value
		Mean	SD	Range	Mean	2 SD	Range	
TC angle	Right	35	4.3	24–46	33.4	8.0	25–42	0.03
	Left	35	4.2	26–48	33.0	8.1	24–40	0.005
C angle	Right	113	5.1	100–127	114.5	11.4	104–126	NS
	Left	114	5.1	103–127	115.7	9.8	102–126	0.04
TM angle	Right	161	4.8	152–171	164.2	9.1	153–172	0.004
	Left	161	4.8	151–170	166.4	9.0	154–178	< 0.0001
Tarsal index	Right	3.5	3.0	0–15.6	9.2	6.7	2.3–16.7	< 0.0001
	Left	4.5	3.6	0–20.6	7.3	8.5	1.0–18.1	0.007

cating higher arches in the probands. The C angle was only slightly smaller in the probands, but also in the direction of higher arches. The tarsal index showed that cavovarus deformities occurred more frequently in probands than in controls.

The limits of normal range were defined from the values of the control group as the mean value ± 2 SD. Thus, feet with cavo or cavovarus deformities have TC angles above mean +2 SD, whereas the TM and C angles and the tarsal index have to be below mean –2 SD. According to these limits, cavus or cavovarus deformities in probands were as follows: TC angle, 14/188 (7.5 percent); C angle, 8/188 (4.5 percent); TM angle, 22/133 (17 percent); and tarsal index TI, 37/188 (20 percent). Twenty ankles with a tarsal index less than mean –2 SD had normal TM angles above mean value –2 SD, ranging from 157° to 166°, implying varus of the hindfoot.

Discussion

The measurements of TC and TM indicate that also deformities in front of the os calcis can cause a high foot arch, i.e., the tarsal-metatarsal relation is likewise important. The lower TI values in probands implies some degree of varus deformity.

The results in this study show that feet with cavus or cavovarus deformity are more frequent in patients with chronic lateral ankle instability than in controls. This accords with the observation that people with such deformities are more prone to supination traumas (Bonnin 1950, Prins 1978). Because weight-bearing radiographs normally are recommended by other authors (Benink 1985, Gamble and Yale 1966, and Gould 1983), the presented values are not directly comparable with these studies. Because the effect of increasing the vertical load in feet with high arches is relatively less than in flat feet (Benink 1985), the used procedures do distinguish between high and low arches of the feet assuming the normal values (the controls) are known.

Discrepancies between feet regarding the prominence of malleoli, the points used for the central beam, may influence the measurements, but van Langelaan (1983) has shown that up to 5° foot rotation only implies changes of less than 1° in the rotation axis. Small changes in the calcanean overlap of the talus head (Pc) may be caused by variations in the shape of the os calcis and/or minor subtalar rotations, and the TI index is extremely sensitive to the changes in Pc. This may explain the differences in TI found between the right and the left ankles. The Pc represents the relative degree of supination (high values) and pronation of the hindfoot (low values). In a calcaneocavus deformity, with pronation of the forefoot, a nonrigid hindfoot must supinate or assume a varus position to achieve a plantigrade position (Samilson and Dillin 1983). With the foot plantar-flexed, Parlasca et al. (1979) noted an average of 2° internal rotation in the talocrural joint; otherwise, the rotation was minimal. These observations coincide with increased stress to the lateral ankle ligaments and with the generally accepted mechanism causing such ligamentous injuries as a plantar-supination-inward rotation trauma (Dehne 1933, Bonnin 1950, Andersson et al. 1962, Broström et al. 1965, Laurin et al. 1975). Also, the relatively short achilles tendon, often found in feet with cavus deformities (Giannestras 1967), implies a more plantar-flexed foot position with less stability in the ankle mortise.

References

Anderson K J, LeCocq J F, Clayton M L. Athletic injury to the fibular collateral ligament of the ankle. Clin Orthop 1962; 23: 146-61.

Benink R J. The constraint mechanism of the human tarsus. A roentgenological experimental study. Acta Orthop Scand 1985; 56(Suppl 215).

Bonnin J G. Injuries to the ankle. W. Heinemann Medical Books Ltd 1950: 104-46.

Broström L. Sprained ankles. A pathologic, arthographic and clinical investigation. VI. Surgical treatment of "chronic" ligament ruptures. Thesis, Karolinska Institute, Stochholm, Sweden 1966: 1-15.

Dehne E. Die Klinik der frischen und habituellen Adduktionssupinationsdistorsion des Fusses. Dtsch Z Chir 1933; 242: 40-61.

Gamble F O, Yale I. Clinical Foot Roentgenology. Williams & Wilkins Co, Baltimore 1966: 215-9.

Giannestras N J. Foot Disorders. Medical and Surgical Management. Lea & Febiger, Philadelphia 1967: 153-5.

Gould N. Evaluation of hyperpronation and pes planus in adults. Clin Orthop 1983; 181: 37-45.

Keim H A, Ritchie G W. Weight bearing roentgenograms in the evaluation of foot deformities. Clin Orthop 1970; 70: 133-6.

van Langelaan E J. A kinematical analysis of the tarsal joints. An X-ray photogrammetric study. Acta Orthop Scand 1983; (Suppl 204).

Larsen E. Tendon transfer for lateral ankle and subtalar joint instability. Acta Orthop Scand 1988; 59(2): 168-72.

Laurin C, Mathieu J. Sagittal mobility of the normal ankle. Clin Orthop 1975; 108: 99-104.

Leliévre J. Pathologie du Pied. Mason et Cie Editeurs, Paris 1961.

Lindstrand A, Mortensson W. Anterior instability in the ankle joint following acute lateral sprain. Acta Radiol (Diagn) (Stockh) 1977; 18(5): 529-39.

Parlasca R, Shoji H, D Ambrosia R D. Effects of ligamentous injury on ankle and subtalar joints: a kinematic study. Clin Orthop 1979; 140: 266-72.

Prins J G. Diagnosis and treatment of injury to the lateral ligament of the ankle. A comparative clinical study. Acta Chir Scand 1978; (Suppl 486): 3-149.

Rose G K. Ankle injuries. In: Modern trends in orthopaedics. Butterworths, London 1962: 155-86.

Rubin G, Witten M. The talar tilt angle and the fibular collateral ligaments. J Bone Joint Surg (Am) 1960; 42: 311-26.

Rubin G, Witten M. The unstable ankle. Bull Hosp Joint Dis 1964; 25: 179-90.

Samilson R L, Dillin W. Cavus, cavovarus, and calcaneocavus. An update. Clin Orthop 1983; 177: 125-32.