Tibiofibular torsion in congenital clubfoot

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Tibiofibular torsion was measured by computed tomography in three series of patients affected by congenital clubfoot who were treated with different protocols. The normal leg of unilateral deformities served as the control. For the bilateral cases, only the right side was included in the study. The angle between the bicondylar axis of the tibia and the bimalleolar axis was the index of tibiofibular torsion. There were 34 clubfeet in the first series, treated with a posteromedial release, and 40 clubfeet in the second series, treated with a modified Ponseti method, whereas the third series included 16 clubfeet, treated with the original Ponseti method. All 90 clubfeet were graded at birth as group 3 according to the Manes classification. No patient had previous treatment. The patients of the first and the second series were followed up to maturity, whereas the patients of the third series were followed up to a maximum of 11 years of age. In the congenital clubfoot, the tibia and the fibula were externally rotated, in comparison with the normal leg; in fact, the average value of the angle of tibiofibular torsion was 32.2° in the first series, 23.9° in the second series, and 21.1° in the third series. In the normal tibiae, the average value of the angle of tibiofibular torsion was 21.4°. The difference between the first series and the normal controls was statistically significant, as was the difference between the first one and the other two series. The value of the tibiofibular torsion angle seems to be related to the manipulation technique used to treat clubfoot: when the manipulation does not allow a progressive eversion of the talus underneath the calcaneus, the external tibial torsion increases. At follow-up, an intoeing gait was present in seven treated clubfeet of the first series. In all of them except one, the highest value of the external tibial torsion angle was observed, with a low value of the Kite's angle and/or residual forefoot adduction. In the treated congenital clubfoot, persistent intoeing is not related to the angle of tibial torsion but rather to the amount of correction of calcaneal inversion and residual forefoot adduction. *J Pediatr Orthop B* **21:47–51 © 2011 Wolters Kluwer Health | Lippincott Williams & Wilkins.**

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Introduction

Many children with treated congenital clubfoot show an intoeing gait when they start to walk, and this abnormal gait may persist in adult life. Internal tibial torsion caused by the internally twisted foot has been considered as a possible cause of intoeing. For this reason, the torsion angle of the tibia has been investigated by various authors in patients with congenital clubfoot [1–6]. Some authors have reported that children with talipes equinovarus have a relatively internal tibial torsion [2–4,7–9], whereas other authors have reported an increased external tibial torsion [1,5,6,10]. Howard and Benson [11] reported a neutral torsion angle of the tibia in stillborns with congenital clubfoot, with no difference from the normal contralateral leg.

The aim of our study was to assess the torsion angle of the tibia and the fibula by computed tomography (CT) in two series of skeletally mature patients affected by congenital clubfoot, who were treated with two different protocols between 1973 and 1987, and in a third series of clubfoot in still growing children treated according to the original Ponseti method from 2000.

Materials and methods

Three series of patients affected by congenital clubfoot were included in the study. For the bilateral cases, only the right side was evaluated. The first series includes 34 clubfeet treated between 1973 and 1977 using a traditional approach [12], the second series includes 40 clubfeet treated between 1979 and 1987 using a modified Ponseti method [13], whereas the third series includes 16 clubfeet treated between 2003 and 2006 using the original Ponseti method [14]. All 90 clubfeet were graded at birth as group 3 according to the Manes classification. Manes group 3 includes the most severe deformities, characterized by a foot difficult to reduce manually, with an equinovarus and supination deformity greater than 45° [15]. No patient had previous treatment. The patients of the first and the second series were followed up to the end of skeletal growth, whereas the patients of the third series were followed up from 4 to 11 years of age. In the first series, 26 patients were men and eight women; the deformity was bilateral in 16 patients and unilateral in 18. In the second series, 28 patients were men and 12 women; the deformity was bilateral in 21 and unilateral in 19. In the third series, 11 patients were men and

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five women; the deformity was bilateral in eight patients and unilateral in the other eight. The average follow-up was 25 years (range from 24 to 28 years) in the first series, 18.8 years (range from 17 to 22 years) in the second series, and 7.8 years (from 4 to 11 years) in the third series. The study was approved by the Ethics Committee of our University Hospital, and informed consent was obtained from the patients or from their parents.

The patients of the first series were treated with manipulation and casting according to the Marino-Zuco technique [12]; foot abduction ranged from -10° in the first cast to $+10^\circ$ in the last cast, total cast immobilization ranged from 3 to 5 months, and the total number of casts from seven to tweleve. In all 34 patients of the first group, after cast immobilization, we performed a posteromedial release according to Codivilla and Turco [16,17]: we lengthened the Achilles tendon, the tibialis posterior, the flexor hallucis, and the flexor digitorum communis, and performed a capsulotomy of the ankle, the subtalar, and the talonavicular joints. An aluminum brace with the knee at 90° of flexion and the foot in 10° of dorsiflexion and 20° of abduction was applied at night until 3 years of age, whereas high-top reverse-last shoes were used until the child was 5 years old. The patients of the second series were treated with manipulation and casting according to the Ponseti technique [14]; the abduction angle of the foot varied from -10° to 0° in the first plaster and from $+50^\circ$ to $+60^\circ$ in the last cast, total immobilization ranged from 1 to 2 months, and the total number of casts from four to six. In all 40 children of the second group, after cast immobilization, we performed a limited posterior release, instead of the subcutaneous tenotomy: we lengthened the Achilles tendon and performed a capsulotomy of the ankle and the subtalar joints. An aluminum brace with the knee bent 90° and the foot in 10° of dorsiflexion and 20° of abduction was applied at night until 4 years of age. All 16 patients of the third series were treated with manipulation and casting according to the Ponseti technique, followed by a subcutaneous tenotomy. A Mitchell brace with the treated clubfoot 70° externally rotated, and the normal foot in the unilateral cases 30° externally rotated, was applied full time until the walking age and then at night until 4 years of age. Relapsing clubfeet of all three series, passively correctable, were treated with transfer of the anterior tibial tendon on the third cuneiform [18], whereas relapsed stiff feet, observed only in the first series, were treated with a second posteromedial release.

At follow-up, all the patients were clinically evaluated for residual intoeing by observing their gait. In case of intoeing, we measured the internal and the external rotation of the extended hip and the position of the ankle and the foot in relation to the patella in a neutral position. We also observed, with the patient standing, the hindfoot and forefoot shape and orientation. The tibiofibular torsion angle was evaluated by CT scan both in clubfeet and in normal feet (LightSpeed Series 5.X; GE Healthcare, Chalfont St Giles, UK) with 3-D reconstruction. The patient was positioned supine on the machine platform with the lower limbs parallel and the knees straight. The feet were locked parallel in a radiolucent support in a neutral position with the ankles at 90°. Scans 1.25 mm thick were taken on the three different spatial planes.

The torsion angles of the tibia and the fibula were evaluated through a 3-D CT scan of the lower limb, by measuring the angle between the transverse axis of the tibial plateau and the bimalleolar axis [19]. Three-dimensional reconstruction of both the leg and the foot was useful for an overall appreciation of the foot and leg relationship in the transverse plane. The senior authors, independently, measured the tibial torsion angle on the axial section obtained at the CT-scan examination in order to calculate the value of the intraclass correlation coefficient.

We determined differences in the values of the internal tibiofibular torsion angle between the three series of clubfeet and normal feet using the *t*-test with a Bonferroni correction for multiple tests. A P value of less than 0.05 was considered to be significant.

Results

Intoeing was observed in seven patients of the first series. Two patients had a bilateral deformity, whereas five had a unilateral deformity. The external/internal rotation of the hip was normal in those patients, whereas the position of the ankle and foot in relation to the patella was normal in all patients except one, with a bilateral deformity, in whom the foot was in 20° of internal rotation in relation to the neutrally oriented patella, but the foot alignment was normal. Looking at the patients' feet in a standing position, the hindfoot was varus and internally rotated while the forefoot was adducted and slightly supinated in six patients. In the patient who had 20° of internal rotation of the foot in relation to the patella, the hindfoot and forefoot were well aligned without varus of the calcaneus or forefoot adduction. No patient of either the second or the third series showed intoeing gait.

In the first series of patients with clubfoot, the average value of the angle of tibiofibular torsion was 32.2° (range: from 0° to 47.5°) (Fig. 1); in the second series, the average value of the angle of tibiofibular torsion was 23.9° (range: from 16.2° to 30.2°) (Fig. 2), whereas in the third series, the average value of the angle of tibiofibular torsion was 21.1° (range: from 13.5° to 28.0°) (Fig. 3). In the normal legs, the average value of the tibiofibular torsion was 21.4° (range: from 13.9° to 29°) in the adults of the first two series (Figs 1 and 2) and 19.8° in the children of the third series (Fig. 3). The difference

Fig. 1

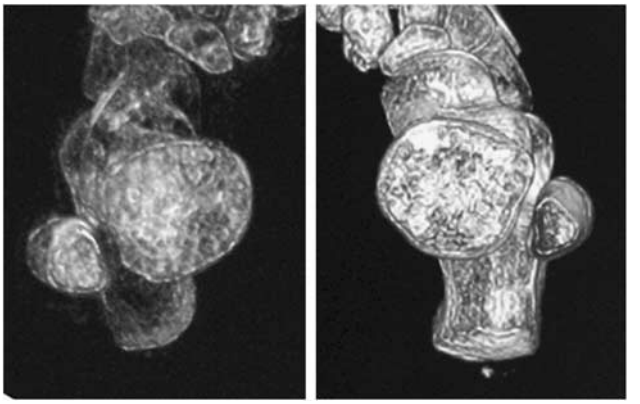
Three-dimensional computed tomography-scan reconstruction of the foot at the level of the ankle in a 24-year-old patient of the first series affected by unilateral clubfoot on the right side. The tibiofibular torsion angle measured 47.5° in the clubfoot and 21.5° in the contralateral normal foot.

Fig. 2

Three-dimensional computed tomography-scan reconstruction of the foot at the level of the ankle in a 20-year-old patient of the second series affected by unilateral clubfoot on the right side. The tibiofibular torsion angle measured 26.5° in the clubfoot and 20° in the contralateral normal foot.

between the first series and the normal limbs was statistically significant (*P*: 0.001), as was the difference between the first and the second series (*P*: 0.001) and the first and the third series (*P*: 0.002). No statistically significant difference was found between the second and the third series and the normal limbs. The tibiofibular torsion measured 0° on the right side and 2° on the left only in the bilateral case of the first series in whom an

Fig. 3



Three-dimensional computed tomography-scan reconstruction of the foot at the level of the ankle in an 8-year-old patient of the third series affected by unilateral clubfoot on the left side. The tibiofibular torsion angle measured 20° in the clubfoot and 18° in the contralateral normal foot.

internal tibial torsion was clinically evident. The value of the intraclass correlation coefficient was 0.77.

Discussion

The most common causes of intoeing in children without neuromuscular disease are internal femoral torsion, internal tibial torsion, metatarsus adductus, and clubfoot sequelae [20]. In the latter condition, internal tibial torsion has been postulated as a possible concurrent factor to intoeing. The torsion angle of the tibia, defined as the angle formed between the bicondylar axis of the proximal tibia and the bimalleolar axis, is an indicator of tibial torsion. This angle has been previously investigated by various means: clinical assessment only [1,2,4–6,9,10,20,21], radiographic examination [1,5,10,22,23], ultrasound [3,24–27], and CT scan [18,21,24,28,29]. According to those studies, the torsion angle of the tibia varies in normal individuals from neutral at birth to a value from 17.4° to 40.5° of external torsion at maturity. However, external tibial torsion has been reported even at birth [30].

The wide range observed for the values of the tibial torsion angle could be attributed either to different methods of measurement or to the fact that in some studies the distal tibiofibular axis was considered, whereas in other studies, the distal tibia alone was considered [3,26]. Certainly, among the various methods of measurement, the CT scan should be the most precise, although it exposes the patient to high radiation absorption; in addition, the distal tibiofibular axis should be more reliable, compared with the distal tibial axis alone. However, some authors [3,26] have reported that the 'true' tibial torsion should be measured by ultrasound, evaluating the plane of the posterior tibial surface instead of the bimalleolar plane. In our study, we evaluated the normal leg of unilateral deformities as a control instead of

evaluating normal participants; this is a limitation of the study, because some authors have found a decrease of the external tibial torsion value in the contralateral normal leg of patients treated for unilateral clubfoot [3].

Despite the fact that no torsion of the tibia has been observed in dissected specimens of stillborns with congenital clubfoot [11], internal tibial torsion has been reported in patients with well-corrected clubfeet or in recurrent, neglected, or maltreated clubfeet, in which intoeing was present. Hutchins *et al.* [2] measured tibial torsion with a torsiometer in treated clubfeet and normal feet. External tibial torsion in patients with treated clubfeet was lower than that of the control group. Moreover, in the latter, the angle of tibial torsion increased from 10° at five years of age to 17.4° at maturity. Krishna *et al.* [3] also reported a decrease in the external tibial torsion in patients with congenital talipes equinovarus compared with a group of normal children, evaluated with ultrasound. The same authors found a decrease in the value of the external tibial torsion in the contralateral normal leg of the patients treated for unilateral clubfoot. In a gait analysis study of 20 children with congenital clubfoot, and 15 control participants, Theologis *et al.* [4] reported a significantly increased internal torsion of the foot during walking (intoeing gait), which was partially compensated by external rotation of the hip. The authors stated that the intoeing gait was related either to a residual forefoot adduction or to an internal torsion of the tibia. Similar conclusions were drawn by Yngve [9], who reported that the feet with significant intoeing had a relatively internal tibial torsion in comparison with the clubfeet without intoeing.

In other studies either the authors found no difference between the normal side and the clubfoot side or they reported an increased external tibial torsion in clubfeet, likely related to the manipulative technique forcing the foot into eversion [1,5,6,10]. In a review of 84 cases affected by congenital clubfoot, Wynne-Davies [6] never observed a tibial torsion beyond the normal range, although the patients with clubfoot tended to have a higher value of lateral tibial torsion. The tibial torsion was measured with a torsiometer, constructed by the author himself. Swann *et al.* [5] and Lloyd-Roberts *et al.* [10] reported the presence of an increased external tibial torsion in patients affected by congenital clubfoot, although residual deformities were present in all these patients. In both studies, tibial torsion was measured by clinical and radiographic methods. Herold and Marcovich [1] studied the tibial torsion angle, using a tropometer, a caliper, and X-rays, in 42 neglected clubfeet of participants from 2 to 17 years of age: the average value of the external torsion angle of the tibia in the clubfoot cases was similar to that of healthy children. The authors also stated that tibial torsion and forefoot adduction were not related.

The CT scan was not used in any of the studies reported immediately above to measure the tibial torsion angle in congenital clubfoot. Nowadays, the CT scan is recognized as the most accurate method of measuring lower limb torsional deformities. In our study, the tibial torsion angle was measured by CT scan, according to the Jakob *et al.* [19] technique. The external tibiofibular torsion was increased in all three clubfoot series in comparison with normal, but the highest value of the tibiofibular torsion angle was observed in the first series, treated with our traditional manipulative technique, followed by posteromedial release. In this series, the difference in the external tibiofibular torsion from the normal controls was statistically significant, whereas in the other two series, no statistically significant difference from normal was observed. The third series had an average value that was lower than normal, but the patients of that series were still growing, and growing individuals have a lower value of the external tibial torsion angle. It is important to note that the Ponseti manipulative technique adopted in the second and third series allows the progressive eversion of the calcaneus under the talus and improves the declination angle of the neck of the talus, whereas our traditional technique blocks the calcaneus underneath the talus. In the first series, the external torsion of the tibia appeared to compensate for the lack of eversion and abduction of the calcaneus underneath the talus, the lack of correction of the declination angle of the neck of the talus, and the forefoot adduction.

Derotation osteotomy of the tibia is not routinely indicated in clubfeet with persistent intoeing [31]. The only indication may be in those rare cases in which a severe internal tibial torsion coexists with congenital clubfoot, as we observed only in one bilateral case (one out of 90 patients).

In conclusion, our study shows that treated congenital clubfeet are usually associated with external tibiofibular torsion, which is more marked in cases of severe residual deformities of the hindfoot and/or forefoot. For this reason, in patients with congenital clubfoot, intoeing gait is not related to the angle of tibiofibular torsion. A coexistence of congenital clubfoot and internal tibial torsion may be observed as a combination of two different pathologic entities.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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