Mutual Position of the Distal Fibular Physis and the Tibiotalar Joint Space – Radiological Typology and Clinical Significance

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Key words
- ankle
- tibia
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- physis
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- injury

Mots-clés
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- articulation tibio-astragalienne
- traumatisme

Palabras clave
- tobillo
- tibia
- fíbula
- fisis
- espacio articular tibiotalar
- lesión

Schlüsselwörter
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- Tibiotalargelenk
- radiologische Typisierung
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Abstract

Aim: The mutual position of the distal fibular physis compared to the tibiotalar joint space in the immature skeleton was investigated in X-ray studies. The clinical relevance of the recorded mutual position was evaluated for paediatric skeletal traumatology.

Materials and Methods: 140 radiographs of immature ankle joints without skeletal injury were reviewed and the mutual position of the distal fibular physis and tibiotalar joint space was tested. We then reviewed a cohort of 30 children with skeletal injuries of both the distal tibial epiphysis and the distal fibula. The type of distal fibular injury was evaluated according to the mutual position of the distal fibular physis and the tibiotalar joint space.

Results: We found that in about one-half of cases the distal fibular physis is located distally to the plane of the tibiotalar joint, which has not been considered in the literature. Thus, we defined three radiological types of immature ankle joint according to the vertical position of the distal fibular physis in relation to the tibiotalar joint space: type 1 – distal fibular physis is above the joint space; type 2 – distal fibular physis is on the same level as the joint space; type 3 – distal fibular physis is below the joint space. In the second cohort, we found that type 2 predisposes to physeal fibular injury and type 3 predisposes to metaphyseal fibular injury. All data obtained were statistically evaluated.

Conclusions: There are three radiological types of immature ankle joint. Type 1 is only an evolutionary type without clinical significance, type 2 predisposes to physeal and type 3 to metaphyseal fibular injury in combination with distal tibial physeal injury.

Introduction

"The distal fibular physis in a boy of eight years was found to lie in a direct horizontal line with the articular surfaces of the tibia and astralgus. It may therefore be said to be almost exactly on a level with the plane of the ankle joint". This was written by John Poland in 1898 [13]. Almost one hundred years later in 1983, Ogden postulated that the distal fibular physis is most often on the level of either the tibial articular surface or the subarticular limits of the tibial ossification centre (the subchondral plate) [12]. An analysis of our X-ray documentation showed that the mutual position of the distal fibular physis and the tibiotalar joint space is more variable. In almost one-half of children, the distal fibular physis reaches the talar dome, i.e., is situated distally to the tibiotalar joint. The clinical importance of this was confirmed, and subsequent therapeutic solutions were proposed.

Materials and Methods

A randomised group of 140 radiographs of children's ankle joints were reviewed. For that review, children with ankle joint sprains (without any skeletal injury) were selected. Patients ranged from infants to adolescents; there were 72 boys and 68 girls. All were without neurological or musculoskeletal impairment. In our work, we correlated the vertical position of the distal fibular physis with respect to the position of the plane of the tibiotalar joint. It is impossible to determine the exact location of the joint space on the basis of plain radiographs. The joint space lies within the visible gap between the joint bones on plain X-ray. Therefore, we accepted the distal

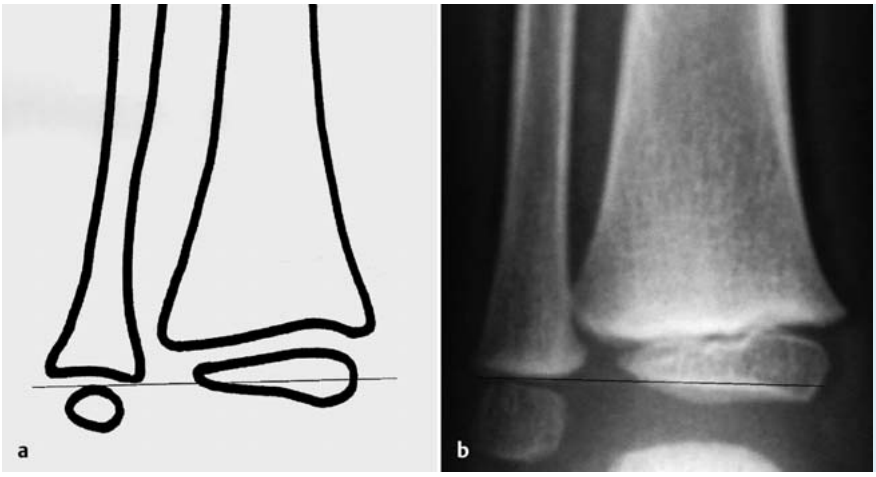

Fig. 1 a and **b** **a** Type 1 – distal fibular physis is above the joint space – sketch. **b** Type 1 – distal fibular physis is above the joint space – X-ray.

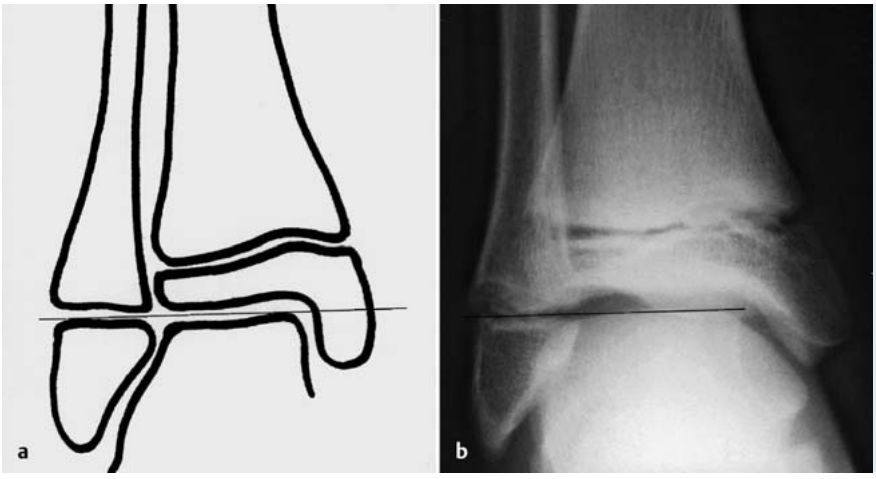

Fig. 2 a and **b** **a** Type 2 – distal fibular physis is at the same level as the joint space – sketch. **b** Type 2 – distal fibular physis is at the same level as the joint space – X-ray.

edge of the distal tibial epiphysis as the upper boundary of the gap and the proximal edge of the talar dome as the lower boundary of the gap. The actual ankle joint space is positioned along the centre of the gap. The distal fibular physis lies between two edges: the distal edge of the distal fibular metaphysis and the proximal edge of the distal fibular epiphysis. We analysed the statistical distribution of the occurrences for each of the three types depending on the child's age (pie charts).

The second cohort consisted of 30 children with skeletal injuries to both the distal tibial epiphysis and the distal fibular physis treated in our department over a period of five years (1999 – 2003). Different types of distal fibular injury (metaphyseal, physeal, epiphyseal) were considered, their relation to distal fibular physis levels were evaluated and the consequent treatment was described. Because of the low number of observations, the Yates' corrected chi-square test was used for statistical evaluation.

Results

In the 140 children tested in the first group, three types of immature ankle joints were established, according to the position of the distal fibular physis (**Table 1**). In the test results, there were no differences between genders.

Type 1 occurred in 13 children; in these children, the distal fibular physis was found to lie proximally to the plane of the tibiotalar joint. The distal metaphyseal and proximal epiphyseal edges of the distal fibula (fibular physis) are on the level of the distal tibial physis or epiphyseal ossification centre (**Fig. 1 a, b**). Eleven of the children (85 %) were under three years of age. Only two girls were aged seven and nine years, respectively.

Type 2 was found in 62 children; in these children, the distal fibular physis was on the same level as the plane of the tibiotalar joint. The distal edge of the distal fibular metaphysis was on the same level as the distal edge of the distal tibial epiphysis. Similarly, the proximal edge of the distal fibular epiphysis was on the same level as the proximal edge of the talar dome (**Fig. 2 a, b**). The ages of all children examined ranged between two years and adolescence.

Type 3 was found in 65 children; in these children, the distal fibular physis was distal to the plane of the tibiotalar joint with the distal edge of the distal fibular physis distal to the plane of the

Table 1 Incidence of the three radiological types of immature ankle joint

	Mean age (y)	N	%
Type 1	2.1	13	9.3
Type 2	7.3	62	44.3
Type 3	10.3	65	46.4

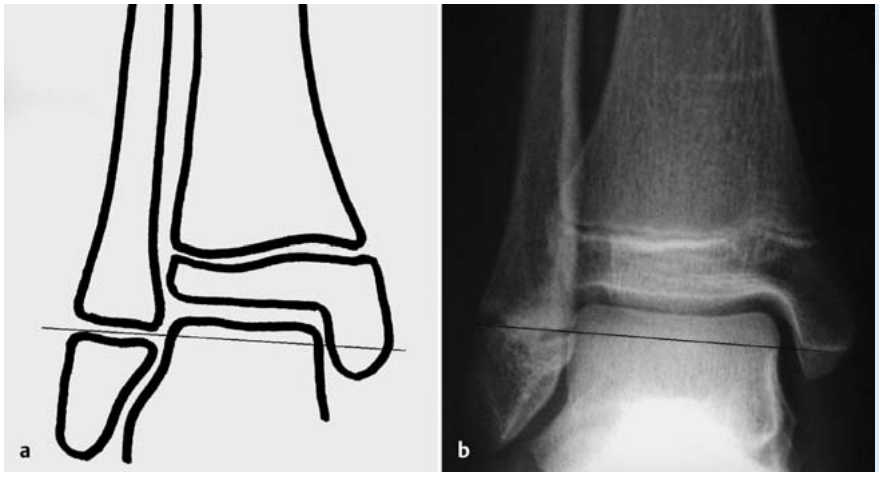

Fig. 3 a and **b** **a** Type 3 – distal fibular physis is under the joint space – sketch. **b** Type 3 – distal fibular physis is under the joint space – X-ray.

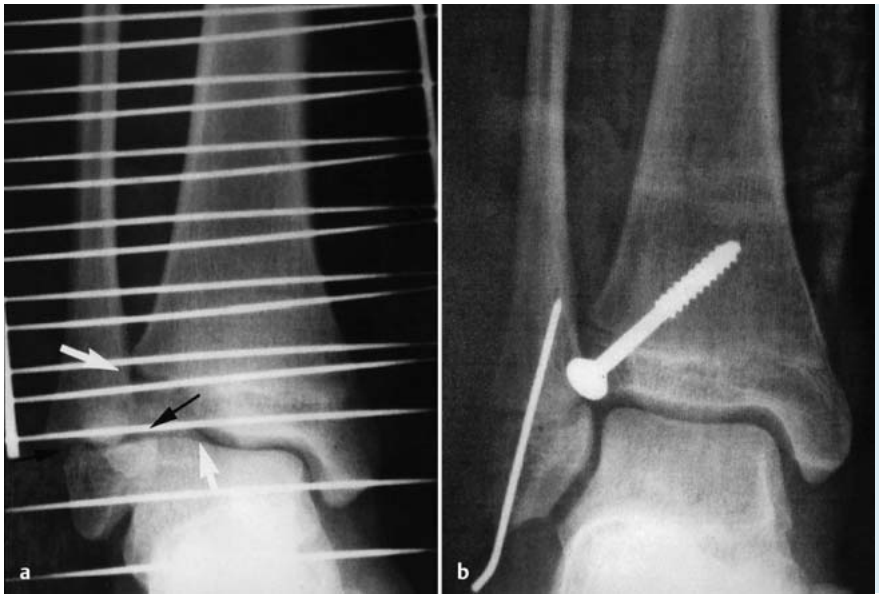

Fig. 4 a and **b** **a** Distal tibial epiphyseal fracture Salter-Harris type III – "Kleiger's fracture" (white arrows) and distal fibular separation Salter-Harris type I (black arrows); X-ray distal tibiofibular type 2. **b** Treated by open reduction and internal fixation (tibia) and closed reduction and percutaneous pinning (fibula).

Table 2 Incidence of radiological types of immature ankle joint for all injured children

	N	%
Type 1	0	0
Type 2	13	43
Type 3	17	57

Table 3 Frequency of occurrence of fibular metaphyseal and physeal injuries in the radiological type 2 immature ankle joint

Type 2	N	%
Fibular physeal injury	10	77
Fibular metaphyseal injury	3	23

tibiotalar joint. The distal edge of the distal fibular metaphysis was on the same level as the proximal edge of the talar dome or distally to it (**Fig. 3 a, b**). Similarly to type 2, the age of all examined children was between three years and adolescence.

The age distribution for each type was analysed statistically. We divided the cohort into three age categories: 0 – 5 years, 6 – 10 years and 11 – 16 years. Graphic diagrams showed the tendency to transformation from one type to another depending on age (**Figs. 6**, **7** and **8**). The radiological type 1 is present predominantly in the first age group and no case of this type was found in the third age group. In contrast, the frequency of occurrence of radiological type 3 increased from the first to the third age group.

In the second cohort, we found that all children with skeletal injuries of both the distal tibial epiphysis and the distal fibula belonged to the group with radiological type 2 immature ankle joint (13 children) and type 3 (17 children). None of them belonged to type 1 (**Table 2**). In type 2, 77% of children suffered from distal fibular epiphyseal separation (**Fig. 4 a, b**). Only 23% appeared to have a distal metaphyseal fibular fracture (**Table 3**). This demonstrates that radiological type 2 predisposes to a physeal fibular injury. A statistically significant difference according to Yates' corrected chi-square test was demonstrated ($p = 0.0003$). In the type 3 group, 94% of patients suffered from distal fibular metaphyseal fracture (**Fig. 5 a, b**). Distal fibular epiphyseal separation was found only in 6% (**Table 4**). This demonstrates that ra-

Fig. 5 a and **b** **a** Distal tibial epiphyseal separation Salter-Harris type II and distal fibular metaphyseal fracture; X-ray distal tibiofibular type 3. **b** Treated by closed reduction and percutaneous pinning (tibia) and closed reduction only (fibula).

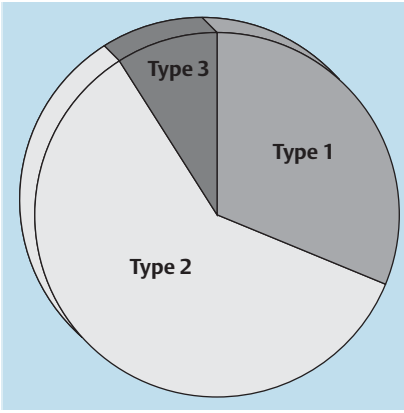

Fig. 6 Distribution of occurrences of each of the types for children aged 0 – 5 years. Note: in this group type 2 (59%) was mostly present, and type 3 (9%) the least present.

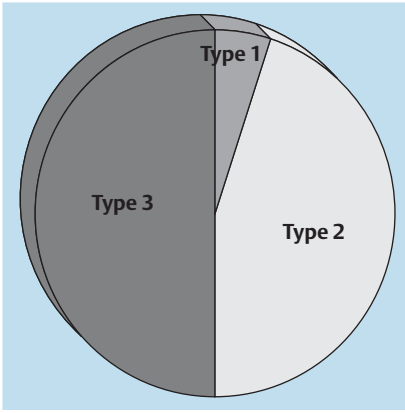

Fig. 7 Distribution of occurrence of each type for children aged 6 – 10 years. Note: in this group type 3 (50%) was mostly present, and type 1 (5%) the least present.

Table 4 Frequency of occurrences of fibular metaphyseal and physeal injuries in the radiological type 3 immature ankle joint

Type 3	N	%
Fibular physeal injury	1	6
Fibular metaphyseal injury	16	94

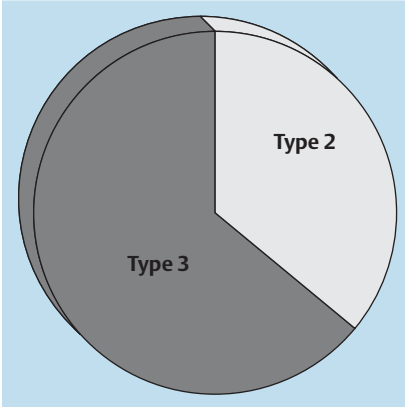

Fig. 8 Distribution of occurrence of each type for children aged 11 – 16 years. Note: in this group type 3 (64%) was mostly present, and no case of type 1 was present.

diological type 3 predisposes to metaphyseal fibular injury. A statistically significant difference according to Yates' corrected chi-square test was demonstrated ($p = 0.0003$).

Discussion

Lauge-Hansen, in 1950, proposed a new classification for ankle fractures in adults. According to his study, three elements are important in ankle injury: axial load, position of the foot at the moment of trauma and the direction of abnormal forces [6]. In 1978, Dias and Tachdjian introduced a new classification using the Lauge-Hansen concepts in children. In order to classify the fracture properly, it is necessary to obtain radiographs with PA, lateral and oblique views. In their classification, the first part of the type name describes the position of the foot at the moment of trauma, and the second describes the direction of the abnormal force applied to the ankle joint [3]. Similarly, the latest treatises classified ankle fractures according to both the anatomy of the fracture and its mechanism [2,4,9,11,16]. Other classifications are based on the subsequent prognosis [15]. Unfortunately, based on our clinical experience, the child is seldom able to recall the exact position of the foot and leg at the time of injury.

Thus, we were searching for a different system which would be simpler than that of Dias. We concentrated on the anatomy of the immature ankle joint, especially on the mutual position of the distal fibular physis and the plane of the tibiotalar joint. Sosna described the descent of the distal fibular physis according to age, but his main interest was on the relationship between the distal tibial and fibular growth plates, and not on the relationship between the distal fibular physis and the ankle joint [14]. Poland, Ogden and Love published an opinion that the distal fibular physis is normally on the same level as the distal tibial articular surface, especially after the second year of life [8,12,13]. But our findings show that in 50% of children the fibular physis extends distally to the tibiotalar joint space. Therefore, we created our classification system to take account of the new findings. It is based on the mutual positions of the distal fibular physis and the tibiotalar joint space. It has a special clinical importance. We reviewed the case reports in the literature and found a number of them that support our theory [2,5,11,13,16]. In adults, complex fractures of the ankle joint have been thoroughly discussed and several therapeutic schedules have been proposed [1,7,10,17]. Weber distinguishes between three types of ankle joint fractures according to the type of fibular fractures [17]. In agreement with this classification, we are certain that the fibula is an important element of the immature ankle joint. In adults, ligament injuries are frequent in this region, as well as syndesmal injuries. In cases of metaphyseal fibular fractures above the syndesmosis, Weber recommends stabilisation of the fibula by open reduction and internal fixation. In contrast, the fibular fracture under the syndesmosis is not so important and often does not require stabilisation by osteosynthesis. In children, the distal fibular metaphyseal fracture is not so important because their strong ligamentous apparatus around the distal tibiofibular junction fully secures the stability of the ankle joint. However, in cases of displaced physeal injury of the distal fibula, especially in radiological type 2 (described above), we recommend stabilisation of the fibula by closed reduction and percutaneous pinning, because in such cases the stability of the ankle joint is severely impaired.

Résumé

Position respective de la métaphyse péronière distale et de l'espace articulaire tibio-astragalien – aspect radiologique et signification clinique

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Buts: La position respective de la métaphyse distale péronière comparée à l'espace articulaire tibio-astragalien chez un squelette immature est appréciée par des études radiologiques. La pertinence clinique de la position observée est évaluée pour la traumatologie pédiatrique.

Matériels et Méthodes: 140 radiographies de l'articulation de la cheville sans lésion squelettique ont été étudiées et la position respective de la métaphyse péronière distale et de l'espace tibio-astragalien a été apprécié. Nous avons alors passé en revue un groupe de 30 patients avec des altérations squelettiques tout à la fois de l'épiphyse tibiale distale et de la partie distale du péroné. Le type de traumatisme était apprécié en fonction de la position respective de la métaphyse péronière distale et de l'espace tibio-astragalien.

Résultats: Nous avons trouvé que dans environ la moitié des cas la métaphyse péronière distale était plus éloignée du plan de l'articulation tibio-astragalienne, laquelle n'est habituellement pas observée dans la littérature. Nous avons défini 3 types de chevilles immatures en fonction de la position de la métaphyse péronière distale en fonction de l'espace articulaire tibio-astragalien: type 1 – la métaphyse est au-dessus de l'espace; type 2 – la métaphyse est au même niveau que l'espace; type 3 – la métaphyse est en-dessous de l'espace. Dans le second groupe, nous avons trouvé que le type 2 prédispose au traumatisme péronien et que le type 3 prédispose au traumatisme de la métaphyse péronière. Toutes les observations obtenues ont été évaluées statistiquement.

Conclusion: Il y a 3 types radiologiques d'articulation de la cheville immature. Le type 1 est seulement un aspect particulier sans signification clinique, le type 2 prédispose aux lésions métaphysaires, et le type 3 prédispose aux lésions métaphysaires associées aux lésions distales péronières.

Resumen

Posición mutua de la fisis fibular distal y del espacio articular tibiotalar – tipología radiológica y significación clínica

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Objetivo: Investigar radiológicamente la posición mutua de la fisis fibular distal en relación con el espacio articular tibiotalar en el esqueleto inmaduro. La relevancia clínica de los hallazgos fue evaluada para su uso en traumatología esquelética pediátrica.

Material y Métodos: Se revisaron 140 radiografías de articulaciones inmaduras del tobillo sin lesiones esqueléticas estudiando la posición mutua de la fisis fibular distal y el espacio articular tibiotalar. Revisamos entonces una cohorte de 30 niños con lesiones esqueléticas del peroné distal y de la epífisis tibial distal. El tipo de lesión fibular se evaluó según la posición mutua de la fisis distal fibular y del espacio articular tibiotalar.

Resultados: Encontramos que en la mitad de los casos la fisis fibular distal se localiza distalmente al plano de la articulación tibiotalar lo que no había sido reflejado en la literatura. Por lo tanto definimos tres tipos radiológicos de articulación inmadura del tobillo según la posición vertical de la fisis distal del peroné en relación con el espacio articular tibiotalar: Tipo I: Fisis fibular distal por encima del espacio articular. Tipo II: Fisis fibular distal al mismo nivel que el espacio articular. Tipo III: Fisis fibular distal por debajo del espacio articular. En la segunda cohorte encontramos que el tipo II predispone a lesiones fisarias fibulares y el tipo III a lesiones fibulares metafisarias. Todos los datos obtenidos se evaluaron estadísticamente.

Conclusiones: Hay tres tipos radiológicos de articulación del tobillo inmadura: el tipo I es solo un tipo evolutivo sin significación clínica. El tipo II favorece lesiones fisarias y el tipo III lesiones metafisarias del peroné en combinación con lesiones tibiales distales.

Zusammenfassung

Die wechselseitige Lage der Fibulaephiphyse und des Tibiotalargelenks – radiologische Typisierung und klinische Bedeutung

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Zielsetzung: Die wechselseitige Beziehung der Fibulaepiphyse zum Tibiotalargelenk wurde radiologisch am unreifen Skelett untersucht. Die klinische Relevanz dieser Beziehung wurde im

Hinblick auf ihre Bedeutung in der Traumatologie des Kindesalters überprüft.

Material und Methodik: 140 Röntgenbilder des unreifen, unverletzten, kindlichen Sprunggelenks wurden im Hinblick auf die wechselseitige Beziehung der distalen Fibulaepiphyse zum Tibiotalargelenk analysiert. Anschließend wurde eine Gruppe von 30 Patienten mit Skelettverletzungen der distalen Tibiaepiphyse und der distalen Fibula untersucht. Die Form der distalen Fibulaverletzung wurde entsprechend ihrer Beziehung zur distalen Fibulaepiphyse und dem tibiotalaren Gelenkspalt ausgewertet.

Ergebnisse: Wir fanden, dass in zirka der Hälfte der Fälle die distale Fibulaepiphyse distal der Ebene des tibiotalaren Gelenkspaltes lokalisiert war, was in der Literatur bisher nicht beachtet worden war. Wir konnten daher entsprechend der Lage der distalen Fibulaepiphyse in Relation zum tibiotalaren Gelenkspalt radiologisch drei Formen eines unreifen, kindlichen Sprunggelenks unterscheiden: Typ I – distale Fibulaepiphyse über dem Gelenkspalt, Typ II – distale Fibulaepiphyse in derselben Höhe wie der Gelenkspalt, Typ III – distale Fibulaepiphyse unterhalb des Gelenkspalts. In der zweiten Patienten-Kohorte fanden wir, dass der Typ II zu einer fibularen Epiphysenverletzung disponiert, der Typ III jedoch zu einer metaphysären Fibulaverletzung. Alle Daten wurden statistisch überprüft.

Schlussfolgerungen: Es gibt drei verschiedene Konfigurationen des unreifen, kindlichen Sprunggelenks. Der Typ I hat keine klinische, sondern nur eine evolutionäre Bedeutung. Der Typ II hingegen prädisponiert zu Epiphysen-, der Typ III zu metaphysären Fibulafrakturen bei gleichzeitiger Fraktur der Tibiaepiphyse.

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