

# Concurrent ipsilateral Tillaux fracture and medial malleolar fracture in adolescence: management and outcome

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## Research article

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## Abstract

## Background

The concurrent ipsilateral Tillaux fracture with medial malleolar fracture in adolescence commonly suffer from high-energy injury, making treatment more difficult. The aim of this study was to discuss the mechanism on injury, diagnosis and treatment of this complex fracture pattern.

## Methods

The charts and radiographs of six patients were reviewed. The functional was assessed by the American Orthopedic Foot and Ankle Society ankle-hindfoot scores.

## Results

The mean age at operation was 12.8 years. The mean interval from injury to operation was 7.7 days. Five Tillaux fractures and all medial malleolar fractures were shown on AP plain radiographs. One Tillaux fracture and two cases with avulsion of posterolateral tibial aspect were confirmed in axial computerized tomography. Talar subluxation laterally with medial space widening in three, and syndesmotic disruption in one. There were five patients sustaining ipsilateral distal fibular fractures. All fractures, except nonunion in two medial malleolar fractures and in one Tillaux fracture, healed within 6–8 weeks. There was one case of osteoarthritis of ankle joint. The average AOFAS score was 88.7.

## Conclusions

Computerized tomography is helpful in identifying the fracture pattern. Anatomic reduction and internal fixation of Tillaux and medial malleolar fracture was recommended to restore the articular surface congruity and ankle stability.

## Background

Physeal injuries of the distal tibia are second in frequency to those of the distal radius and carry a high risk of complications. Tillaux fracture accounts for approximately 2.9–6.7% of the distal tibial epiphyseal fractures [1, 2]. It usually occurs in adolescents when the center and medial side of the distal tibial physis have been closed and the anterolateral quadrant fusion does not occur. The mechanism of injury involved external rotation of the foot contributing to the avulsion of the anterior inferior tibiofibular ligament (AITFL). The pediatric medial malleolar fractures (MMF) usually involved the growth plate, often Salter-Harris I or II fractures, and carried the highest risk of complication for the premature physeal closure (PPC) [3–5]. Whereas, fractures of other parts of the medial malleolus have received sporadic attention in the literature for lower rate of growth disturbance and non-weightbearing area. However, the medial malleolus plays an important role in ankle stability as a bony restraint [6].

Isolated fractures, aforementioned, are usually suffering from indirect force with particular foot position. Direct or high-energy trauma to the ankle may result in special injury configurations. Recently, Gourineni and Gupta [7] reported that six out of eight Tillaux fractures had associated with talar subluxation (TS), lateral malleolar fractures. To our knowledge, there has been no report regarding to the combination of Tillaux fracture and MMF in adolescence. It was the purpose of this study to report the experience of a pediatric trauma center in an attempt to discuss its mechanism of injury, diagnosis, and treatment options.

## Methods

This study was approved by the ethics committee of the Children's Hospital of Soochow University. Six cases of Tillaux fracture associated with MMF were treated from January 2015 to December 2018. The charts and radiographs of six patients were reviewed retrospectively. Clinical data, including age, sex, mechanism of injury, and methods of treatment were collected (Table 1). There were three boys and three girls, with a mean age at operation of 12.8 years (range, 12 to 14 years). The left side was involved in three and the right in three. One patient was hurt while falling down, three during sports of sliding or soccer, two in a motor vehicle accident. The mean follow-up was 11.7 months (range, 6 to 27 months).

Table 1  
Patient demographic data

No.	Gender	Age (y + m)	Interval (d)	Lateral	Cause	Associated injuries	TMM	DT (mm)	SD	Treatment	Complications	Follow- up(months)	AOFAS
1	F	14 + 11	3	L	traffic		S-H III	5.6		ORIF	—	6	96
2	F	12 + 9	6	R	sliding	distal fibular Fx;  TS	H-B	8	no	ORIF  P + S	—	13	90
3	M	14 + 11	5	L	traffic	distal fibular Fx	H-C	2	no	ORIF	—	8	96
4	F	12 + 1	5	R	sliding	distal fibular Fx,  avulsion of PLTA,  TS	H-C	9.4	no	ORIF  P + S	Nonunion of medial malleoli	10	90
5	M	13 + 1	20	R	falling	distal fibular and S-H I epiphyseal Fx,  TS	H-C	8.2	yes	Traction  P + S	Nonunion of Tillaux and medial malleoli, instability, OA	27	64
6	M	12 + 10	7	L	soccer	distal fibula Fx,  avulsion of PLTA	H-C	8.8	no	ORIF	—	6	96
Fx, fracture; TS, talar subluxation; PLTA, posterolateral tibial aspect; ORIF, open reduction and internal fixation for Tillaux and/or medial malleolar fractures;													
P + S, plate + screws for distal fibular fracture; TMM, type of medial malleolar fracture; DT, initial displacement of Tillaux fragment; SD, syndesmotric disruption. OA, osteoarthritis.													

Anteroposterior(AP), lateral plain radiographs and computerized tomography (CT) were performed in all patients to identify the fractures. Axial CT views were reviewed for displacement of Tillaux fractures in the maximal gap section in millimeters and to identify the inferior tibiofibular syndesmosis disruption (SD) and the avulsion of posterolateral tibial aspect (PLTA).

MMF were classified according to Salter-Harris epiphyseal injury (S-H) when the physis was involved[8]. Otherwise, Herscovici classification(H), based on the level of MMF, was used: type A, fracture being avulsions of the tip; type B, between the tip and the level of the plafond; type C, at the level of the distal plafond of the tibia; type D, extended vertically above the plafond[6]. TS was considered if medial joint space of the ankle was greater than the superior ankle space in AP plain radiographs or coronal CT scans [8].

For Tillaux fracture, open reduction was performed through an anterolateral ankle approach and anatomical reduction was obtained and maintained by Kirschner wires (K-wires). Closed reduction and K-wires fixation were undergone for MMF. If necessary, open reduction and internal fixation(ORIF) of the fibular fracture was done with plate and screws. Postoperatively, a short-leg cast was applied and the patients were instructed not to bear weight for 6–8 weeks.

Functional assessment was by American Orthopedic Foot and Ankle Society (AOFAS) ankle-hindfoot scores which consists of pain (40 points), function(50 points), and alignment of the involved ankle (10 points) [9].

## Results

Of six patients, five Tillaux fractures and all MMF were shown on AP plain radiographs. Tillaux fracture in one and avulsion of PLTA in two were confirmed in axial CT. AP plain radiographs showed TS laterally with medial space widening in three patients. In one patient, the axial CT showed SD. There were five patients sustaining ipsilateral distal fibular fractures.

All Tillaux fragments were rotated laterally and the mean initial displacement was 7 mm (range, 2.0 to 9.4 mm) in axial view. Out of six MMF, one was S-H III fractures, one H-type B and four H-type C. Both avulsion of PLTA had minimal displacement.

The mean interval from injury to operation was 7.7 days (range, 3 to 20 days). For Tillaux fracture, five cases were treated with ORIF with K-wires, and one without internal fixation owing to 20 days interval after injury for significant soft tissue compromise. For MMF, open reduction and K-wire fixation was undertaken in S-H III fracture, five closed reduction and K-wire fixation for H-type B and C. One failed to be fixed due to technique error. Of the five fibular fractures, open reduction and fixation with plate and screws were needed to stabilize the ankle joint in three associated with TS laterally. Syndesmotomic fixation was not used for SD and neither of the avulsion of PLTA was fixed for small fragment.

None of the patient suffered deep infection. All fractures, except two instances of nonunion in MMF and one in Tillaux fracture, healed within 6–8 weeks. All three patients with TS showed complete reduction of medial joint space post operation. Radiographs of this child without reduction of Tillaux and MMF demonstrated a valgus of ankle joint, hindfoot instability, and radiographic sign of osteoarthritis. Neither PPC nor leg length discrepancy developed in any of the patients.

The AOFAS score was 88.7 (64 to 97) at the final visit (Table 1). Typical cases were shown in Figs. 1, 2 and 3.

## Discussion

We reported on case series of patients sustaining Tillaux fracture associated with MMF. This study showed that the mean AOFAS score of this complex fracture was 88.7, being comparable to the results reported in other series sustaining isolated fractures[5, 10].

In present series, most of the injury resulted from high-energy forces across the ankle joint. Even though the position of the foot immediately at the injury was uncertain, the external rotation forces be applied in all of the six cases and caused Tillaux fracture. When the force continued to be sufficient, the distal fibula will mostly appear a short oblique fracture and the posterior tibiofibular ligament was stretched to create the avulsion of PLTA, being similar to Volkmann fracture in adult[11]. In addition, PLTA will also result from plantar flexion force[12]. But this usually involves more displacement and a larger fragment. Extreme external rotation of the talus will create MMF in adolescence[7, 13]. In this series, four MMF lines lied adjacent and parallel to the level of distal tibial plafond. This may be the result of the impingement between the talus and the medial malleolus[14].

In general, the diagnosis of MMF and fibular fractures may be easily detected on plain radiographs. Tillaux and PLTA fracture, however, will be missed due to the superimposition of the fibula. Furthermore, as an intraarticular fracture of Tillaux fracture, it may be difficult to evaluate the actual amount of the displacement and the direction with the plain radiographs. Horn et al[15] compared the accuracy of CT and plain radiographs in evaluation of juvenile Tillaux fractures in cadaver specimens. They concluded that CT was more sensitive than plain radiographs in detecting fractures with more than 2 mm of displacement. Moreover, CT can reveal the true dimensions and displacement of these fragments. In present study, the diagnosis of Tillaux fracture in one and both of the avulsion of PLTA were missed in plain radiographs, however, identified on axial CT. We recommended that CT scanning will be extremely paramount to demonstrate the fracture clearly and be helpful to make decision in treatment for cases of high-energy ankle injury.

There was commonly significant edema of the soft tissue following high-energy injury and the wound infection and necrosis rates up to 33%[16]. Miller et al[17] recommended that surgery be delayed to seven to 14 days until the soft-tissue edema has decreased. Meanwhile, strategy of staged treatment for severe ankle injury has been reported in good to excellent outcomes in adults[18]. This may be a dilemma for pediatric ankle fractures due to open physis. Although Crawford[19] noted that Tillaux fracture could be reduced 5 weeks later, reduction for physeal fractures was recommended generally not to be performed after five to seven days to minimize the PPC[3, 10]. In our series, surgery were undertaken in five cases with three to seven days between the injury and operation. Significant swelling was encountered in one case and the surgery was delayed until 3 weeks resulting in nonunion of MMF and Tillaux fracture.

Hanhisuanto et al[20] recommended that more than 2 mm displaced fractures be treated operatively for MMF. In our series, the initial displacement for Tillaux fracture was more greater(2-9.4 mm) than 2 mm due to the high-energy force, and all cases exception one were performed by open reduction and K-wires fixation. The result was comparable with the fixation of screws[19,21]. Our study showed that four cases obtained bony union with closed reduction and K-wire and one nonunion because of no reduction or technique error. Hence, we found that it is of significant importance to fix MMF.

In five distal fibular fractures, three patients with TS were immobilized with plate and screws to restore and maintain the mortise. The widening of medial joint space and TS were reduced to normal in two cases with reduction of the fractures. SD was detected in one case on preoperative axial CT and persistent diastasis was confirmed postoperatively(Fig. 3). This may be the result of Tillaux fracture and MMF being not reduced and fixed.

There were rare reports with respect to the avulsion of PLTA in adolescence. In adult, treatment of posterior malleolus is determined by several factors, such as the size of fragment, the fracture gap, and the step-off of the joint surface[13,22]. Von Hooff[22] et al found when the posterior malleolar fracture fragments was more than 5% and the step-off more 1 mm, osteoarthritis occurred more frequently. Donken et al[23] reported a good long-term clinical and radiological result treated conservatively with closed reduction and cast. In present series, we found no displacement and no fixation was undergone for both cases.

One study of intra-articular physeal injury of the ankle by Caterini et al[24], with an average follow-up of 27 year, showed radiographic osteoarthritis signs in 11.8%. They found that the initial displacement and the quality of reduction were the main risk factors that determined the results. In our study, one child developed posttraumatic osteoarthritis due to the malreduction of Tillaux fracture and instability of the ankle. Furthermore, this case suffered from falling that may cause significant cartilage damage.

In conclusion, simultaneous Tillaux fracture and MMF in adolescences is rare and has not been previously reported. Diagnosis at the initial admission using plain radiographs are challenging, and CT is recommended. It is the recommendation of this study that ORIF can be efficacious for joint congruity.

## Abbreviations

AITFL: anterior inferior tibiofibular ligament

MMF: medial malleolar fracture

PPC: premature physeal closure

S-H : Salter-Harris epiphyseal injury type

H: Herscovici classification

AP: anteroposterior

CT: computed tomography

PLTA: posterolateral tibial aspect

K-wire: Kirschner wire

TS: talar subluxation

SD: syndesmotomic disruption

ORIF: open reduction and internal fixation

## Declarations

Ethics approval and consent to participate in present study was approved by the Ethics Committee of Children's Hospital of Soochow University. Written informed consent was acquired for all patients.

Consent for publication

Not applicable.

Availability of data and material

All data generated or analysed during this study are included in this manuscript.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

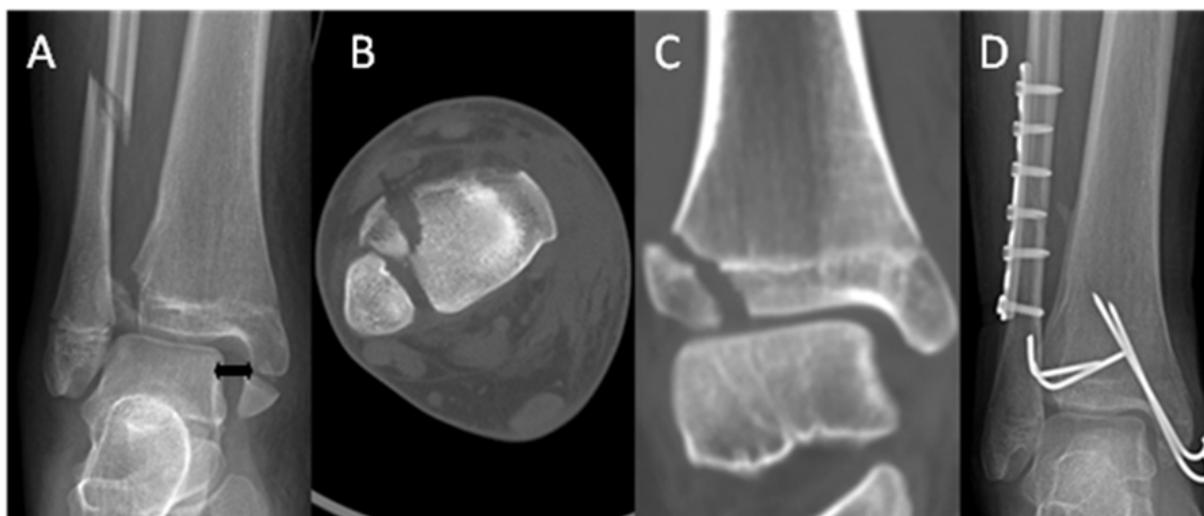
YZ contributed to the study design and is the corresponding author. QY and XW contributed to the study design, data analysis and interpretation, and manuscript draft. ZG, JD, FZ and JF contributed to the data collection and analysis. CY contributed to the data collection and analysis. WY contributed to the literature search and manuscript revision. All authors have read and approved the final manuscript.

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## Figures



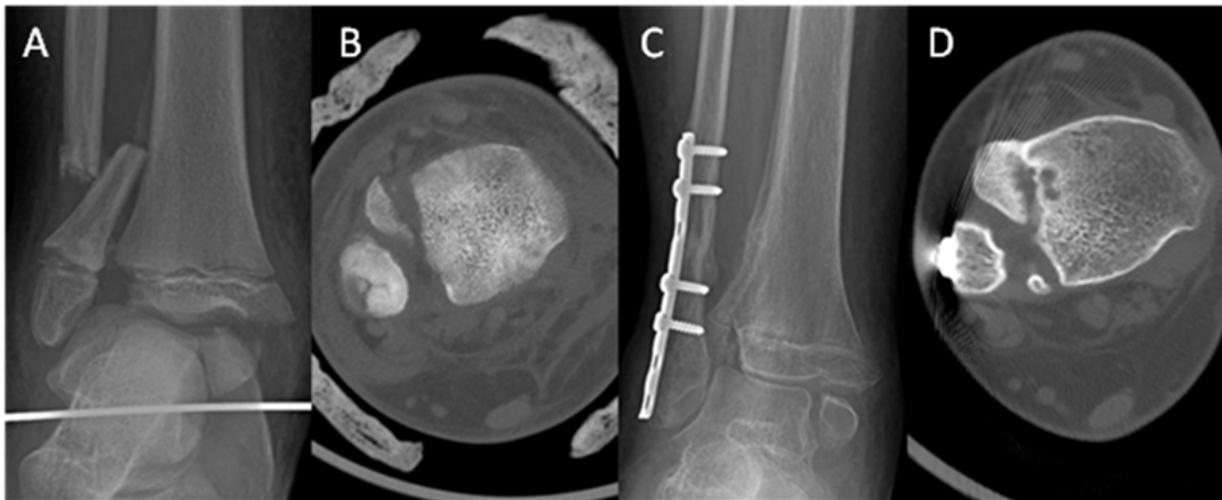
**Figure 1**

(Case 2): A, AP radiograph showed Tillaux fracture, distal fibular fracture, and MMF associated with widening of the tibiofibular clear space and medial space of the ankle (black double arrow). B, Axial CT section showed 8mm displacement of Tillaux fragment and a normal incisura fibularis. C, Coronal CT

scan showed widening of the medial clear space of the ankle, which indicates TS. D, AP plain radiograph obtained 12 months after treatment showed complete reduction of medial joint space immediately post operatively.



**Figure 2**  
(Case 4): A, AP radiograph showed Tillaux fracture, distal fibular fracture, and MMF associated with widening of the tibiofibular clear space and medial space of the ankle. B, Lateral view showed a radiolucent zone consistent with a fracture at the posterior aspect of the tibia (arrows), but it was not clear because of superimposition of the fibula. C, Axial CT section showed 9.4mm displacement of Tillaux fragment, a normal incisura fibularis and avulsion of PLTA with intact medial cortex. D, AP plain radiograph obtained ten months after treatment showed complete reduction of medial joint space immediately post operatively. MMF was not fixed by the K-wire due to technique error.



**Figure 3**  
(Case 5): A, AP radiograph showed Tillaux fracture, distal fibular fracture, and MMF associated with widening of the tibiofibular clear space and medial space of the ankle. B, Axial CT section showed 8.2mm displacement of Tillaux fragment, and SD. C, AP plain radiograph obtained 27 months after treatment of the initial fracture showed nonunion of the Tillaux fracture and MMF and persistent TS. D, Axial CT section confirmed the nonunion of the Tillaux fragment and the persistent diastasis of the distal tibiofibular joint.