

Traumatic Floating Bone. About 11 Cases and a Literature Review

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Abstract

Introduction: Floating bone injury or bipolar dislocation is a concurrent dislocation at both ends of a long bone or a flat bone. It is an exceptional injury. We report 11 consecutive cases of floating bones. **Objectives:** The aim of the study is to analyze the frequency, the mechanism of injury and clinical forms of floating bones, and to present the results of their management.

Material and Methods: A ten years ongoing retrospective study was held in four trauma departments. Eleven cases of floating bones were identified. The floating bones characteristics such as the injured bone, the patient age and sex, the mechanism of injury, the dislocations directions, the associated complications, the treatment and the outcome were studied. **Results:** Nine male and two female patients, with a mean age of 37 years [19 - 65 years range] presented a concurrent bipolar dislocation of one bone or a group of bones. They sustained a road traffic accident ($n = 5$), a workplace accident ($n = 3$), a fall from height ($n = 2$), and a sport accident ($n = 1$). The clavicle ($n = 3$) and the first metatarsal ($n = 3$) were the most frequently involved. The others floating bones were the radius-ulna complex ($n = 1$), the radius-lunatum complex ($n = 1$), the first metacarpal ($n = 1$), the first phalanx ($n = 1$) and the femur ($n = 1$). The floating bones ends displacement occurred in the sagittal plane (the forearm, the femur, the first phalanx and the first metatarsal) and in the horizontal plane (the clavicle, the first metatarsal and the first metacarpal). We defined direction displacements as bidirectional asymmetric ($n = 10$) or unidirectional symmetric ($n = 1$). Associated complications were fractures (wrist, hip, tarso-metatarsal joints) and wounds (fingers, metatarso-phalangeal joint). Dislocations were treated conservatively ($n = 5$) and surgically ($n = 17$) with excellent results ($n = 13/16$ joints). Three patients were lost of view. **Conclusion:** Our study described the characteristics of

this exceptional injury. For any joint dislocation, we promote the systematic examination of the other end of the dislocated bone.

Keywords

Traumatic Dislocation, Floating Bone, Bipolar Dislocation, Clavicle, First Metatarsal, Forearm, First Metacarpal, First Phalanx, Femur

1. Introduction

The bipolar dislocation is permanent displacements of a long bone or a flat bone from their two ends joint. This two-side dislocation occurs as a one-time injury [1] [2] [3] or two-time injury [4] [5]. The isolated bone is so called a “floating bone” [2] [5] [6]. It is an exceptional injury usually published as case report [1]-[34].

The aim of our study was to study the frequency, the mechanism of injury, and the clinical presentations and to report results of orthopedic and/or surgical treatment.

2. Patients and Methods

A ten years (March 2003 to February 2012) ongoing multicentric retrospective study was held in trauma departments of four Senegalese hospitals (One University teaching hospital in the capital and three regional hospitals).

Eleven cases were identified:

- Eight cases were found among 102,511 trauma cases and among 2369 dislocations cases at the trauma department of the University teaching hospital of Grand Yoff in Dakar;
- The others cases were found at the trauma departments of Regional Hospitals of Thiès (n = 1), Kaolack (n = 1) and Tambacounda (n = 1). The total of dislocations cases in these regional hospitals was unavailable.

The studied variables were the injured bone, the patient age and sex, the mechanism of injury (MOI), the dislocations directions, the associated complications, the treatment and the outcome.

3. Results

3.1. Epidemiology

The mean age at the trauma time was 37 years [19 - 65] and the male to female ratio was 5.5:1. The floating bones represented 0.007% of trauma cases and 0.3% of dislocations cases.

3.2. Mechanism of Injury (MOI)

The main MOI was a high velocity axial load (n = 9) during traffic accidents (n = 5), falls from height (n = 2) and workplace accidents (n = 2). The others

circumstances were a simple fall on a sport field ($n = 1$) and on a workplace ($n = 1$). The exact mechanism remained unclear but we retained an indirect mechanism with a successive dislocation.

3.3. Clinical Presentations and Complications

The dislocations were occurred in the sagittal plane ($n = 6$) or in the horizontal plane ($n = 5$). The direction of two dislocations was unidirectional and symmetric in the case of floating first phalanx of the second finger. It was bidirectional crossed and asymmetric in the other cases ($n = 10$).

The more dislocated bones were the clavicle ($n = 3$) and the first metatarsal ($n = 3$). The femur ($n = 1$), the radius-ulna complex ($n = 1$), the radius-ulna-lunatum complex ($n = 1$), the first metacarpal ($n = 1$) and the first phalanx of the second finger ($n = 1$) were less touched (Figure 1).

The floating clavicle displacement was regularly bidirectional asymmetric crossed with a postero-superior displacement of its acromial end and an antero-inferior displacement of its sternal end (Figure 2).

The floating metatarsal displacement was diversified. Its tarsal end was displaced inward with a fracture of the second metatarsal ($n = 2$) (medial cuneometatarsal joint medial dislocation) or upward ($n = 1$) (medial cuneometatarsal joint dorsal dislocation). Its phalangeal end was still displaced downward ($n = 1$) (first metatarsophalangeal joint dorsal dislocation) or outward and downward ($n = 2$) (first metatarsophalangeal joint dorsolateral dislocation) with respect of the sesamoid bones (Figure 3).

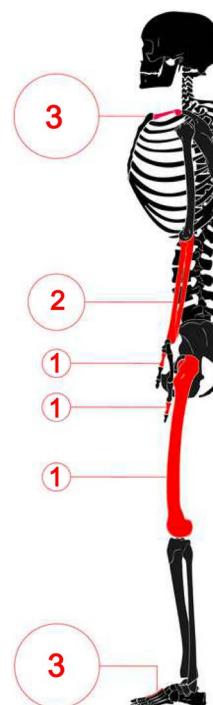


Figure 1. Floating bones topography distribution. Number of case in circle (courtesy of Malick Diallo).

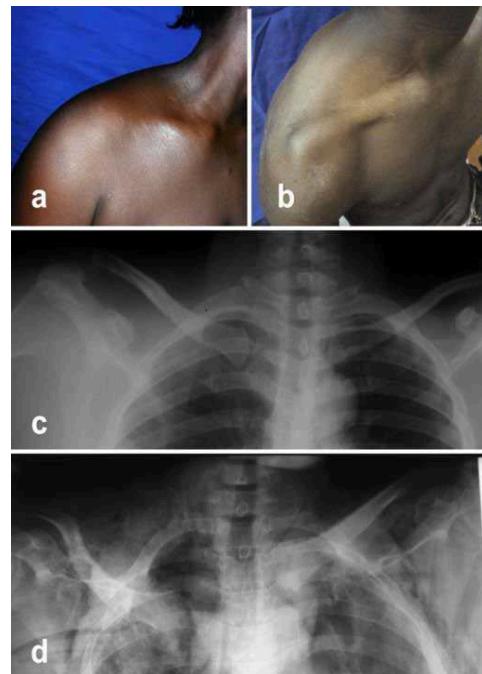


Figure 2. Floating clavicles. ((a) and (b)): Clinical presentations showing a floating right clavicle in a 40 years-old female (Case No. 3) and a floating right clavicle in a 19 years-old male (Case No. 2) respectively. (c) AP view of a thorax grid showing a right floating clavicle (Case No. 3). (d) AP view of a thorax grid showing a left floating clavicle (Case No. 2).

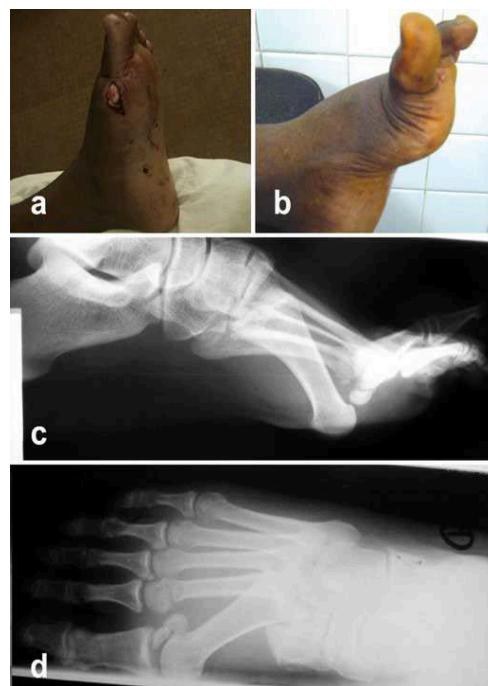


Figure 3. Floating first metatarsals. (a) Clinical presentation. Medio-laterally displaced floating left first metatarsal with the head of the first metatarsal herniated through a wound on the medial side of the foot (Case No. 5). (b) Clinical presentation. Dorso-plantarly displaced floating left first metatarsal with a sagittal Z deformity (Case No. 4). (c) Lateral view of a foot showing an asymmetric floating first metatarsal (Case No. 4). (d) AP view of a right foot showing an asymmetric floating first metatarsal (Case No. 6).

The floating forearm displacement was bidirectional crossed and asymmetric. Its humeral end was displaced postero-laterally (elbow-joint posterolateral dislocation) and its carpal end was displaced antero-medially (posterior radiocarpal dislocation associated to a complex distal radius fracture and posterolateral perilunate dislocation) (**Figures 4(a)-(c)**). The floating femur displacement was bidirectional crossed and asymmetric. Its iliac end was displaced backward and upward (posterosuperior hip-joint dislocation with an associated fracture of the posterior wall of the acetabulum) and its tibial end was displaced frontward (posterior knee-joint dislocation) (**Figure 4(d)** and **Figure 4(e)**). The floating first metacarpal displacement was bidirectional crossed and asymmetric. Its trapezial end was displaced backward and outward (posterior trapeziometacarpal joint dislocation) and its phalangeal end was displaced frontward (posterior inter-phalangeal joint dislocation of the thumb) (**Figure 5(a)** and **Figure 5(b)**). The floating first phalanx of the second finger displacement was unidirectional and symmetric. Its metacarpal and phalangeal ends were displaced backward (posterior metacarpophalangeal joint dislocation and anterior proximal inter-phalangeal joint dislocation of the third finger) (**Figure 5(c)** and **Figure 5(d)**).

It was four open dislocations (hand and foot) and two fractures (the acetabulum and the second metatarsal bone).



Figure 4. Floating forearms and a floating femur. (a) Lateral view showing an asymmetric floating radio-ulnar complex with an associated fracture of the distal radius (Case No. 7). ((b) and (c)): Lateral views of a left elbow and wrist showing respectively a posterior elbow and a perilunate dislocation (Case No. 8). ((d) and (e)): A Pelvic and a right Knee AP views showing respectively a posterior hip fracture-dislocation and a posterolateral knee dislocation (Case No. 9).



Figure 5. A floating first metacarpal and a floating first phalanx. ((a) and (b)): AP and Lateral view of a left thumb showing an asymmetric floating first metacarpal (Case No. 10). ((c) and (d)): Clinical presentation and an AP view of a left hand showing an asymmetric floating first phalanx of the second finger (Case No. 11).

3.4. Treatment and Outcome

All joints dislocations were reduced in emergency with or without anesthesia. We chose to reduce the distal joint before the proximal joint. Closed reductions by external manoeuvre were performed for the femur (knee and hip), for the forearm (two-times on the elbow-joint and one-time for the perilunate dislocation) and for the first metatarsal (one-time for the cuneo-metatarsal joint). The closed reduction of the femur was followed by three weeks transosseous traction. In the other cases (the clavicles, the remaining first metatarsals, the first metacarpal and the first phalanx of the index), open reductions were performed (**Figure 6**). Surgical reductions focused sesamoids incarceration (metacarpophalangeal joint), ligaments reparation (hand and foot) and temporally internal fixations. Non absorbable trans-osseous sutures and four to six week pinning was used as internal fixation methods. One ligamentotaxis exofixation was used for the wrist fracture dislocation.

Closed reduction cases gave good results with two exceptions. The hip fracture dislocation and the knee dislocation were unstable. Open reduction and internal fixation cases with pins removal at 4 - 6 weeks did not presented residual instabilities.

Nine patients were monitored with 19 months mean follow up time (3 months to 6 years). Three patients were lost of view (the floating first phalanx, the floating first metacarpal and the floating radius-lunatum complex). Functional results were excellent in 13 joints. It was two fair functional results (Hip and wrist). They presented a wrist reflex sympathetic dystrophy and a hip post traumatic arthritis. The knee dislocation outcome was poor with a chronic instability and osteoarthritis.

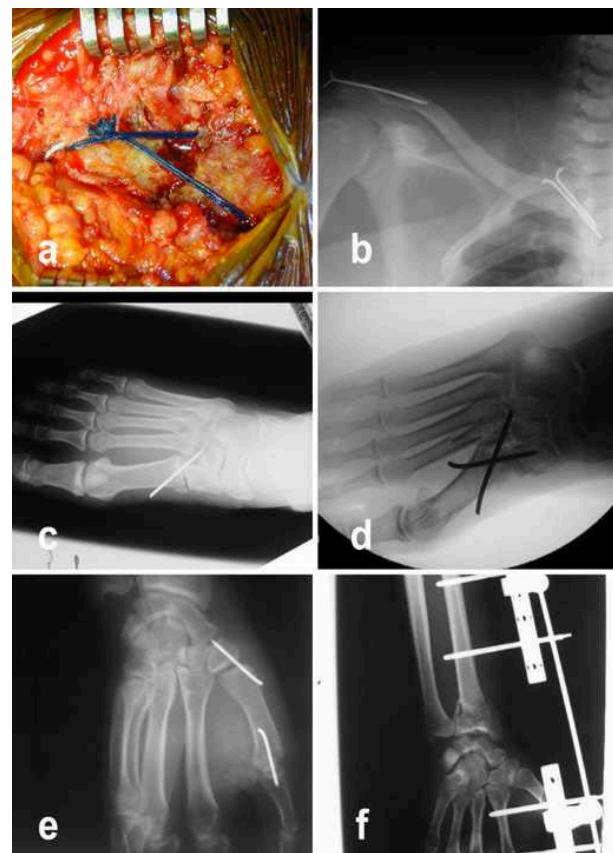


Figure 6. Surgical treatment of a floating clavicle ((a) and (b)), a floating first metatarsal ((c) and (d)), a floating first phalanx (e) and a floating forearm (f).

4. Discussion

This retrospective study have some limits linked to the numbers of patients despite the long observational period. The rarity of this lesions and its exceptional report in literature give to this case serie a certain value to be commented.

4.1. Nosology

The complete dislocation of a long or a flat bone at their two ends frees the bone and makes it “floating”.

Porral [9] in 1831 first describe this injury on a clavicle and Jain [5] called it a “floating clavicle” in 1984. By analogy with the clavicle, Liebner [6] described the “floating first metatarsal” in 1997. Many other names were also used to name this rare injury: “coupled dislocation” [35], “pan-disclocation” [4], “double dislocation” [5] and “bipolar dislocation” [8]. Whenever, this injury might be distinguished from “a floating joint” which means fractures above and below a joint [36].

4.2. Epidemiology

Traumatic floating bones are exceptional injuries. The most injured bones could

be divided in three groups. The first group with a true freed long bone includes the clavicle [3] [5] [9], the first metatarsal [6] [9] [13] [35], the femur [17] [34], the humerus [18] [32], the first metacarpal [19], the fifth metacarpal [20], the second metacarpal [21], the third metacarpal [22], the fourth metacarpal [35], the fifth metatarsal [35], the isolated ulna [23], the fibula [24], the first phalanx [25], the second phalanx [26], etc. The second group with a freed group of bones includes the forearm (radius-ulna complex [27] [28] or radius- ulna-lunatum complex [15] [29] and the leg (tibia-fibula-talus complex) [30]. The third group with a true freed flat bone included the ilium [31].

4.3. Mechanism of Injury

Three conditions are necessary to produce a floating bone: a high energy trauma, a strong bone and a suitable position. The position determinate the anatomical form. Motor vehicle accidents [3] [4] [7] [8] [10] [11] [12] [13] [16] [17] [18] [20] [27] [29] [34] and falls from height [2] [14] [15] [19] [21] [25] [26] [28] [30] [32] are commonly reported. Two main theories were evocated: the simultaneous theory [1] [2] [3] and the successive theory [4] [5].

The successive dislocations theory: on the upper and lower limb, mechanical constraints in forced hyper-flexion and axial load dislocate firstly the distal joint. Then, the distal end act as fulcrum and the dislocation of the proximal end occurs. The muscular insertion determinates displacements directions. Sometimes, compressions or twisted constraints are present. On scapular and pelvic grid, constraints are compressions and axial loads. We think that the associated constraints in flexion and compression and the twisted constraints create bidirectional crossed asymmetric dislocations.

The simultaneous dislocations theory: compressions constraints are absorbed by a solid bone as a deforming energy.

Then, the bone finds back its normal form by transferring this deforming energy to its ends and frees itself from its joints attachments [3]. This might explain the unidirectional symmetric displacement.

4.4. Clinical Presentations

4.4.1. Anatomy

To avoid confusion, we consider displacements of the floating bone ends and not joint displacements. So, a dislocation on a floating bone distal end has an inverted direction of this distal joint dislocation. In the unidirectional symmetric dislocations, the two ends of a floating bone have a same dislocation direction. In the bidirectional asymmetric dislocations, the two ends of a floating bone have an opposed dislocation direction. The bidirectional asymmetric dislocation was more reported in literature [1] [3]-[8] [11] [13] [14] [15] [16] [19] [21] [22] [27] [28] [29] [30] [33]. The unidirectional symmetric dislocation was reported in the floating humerus [18] [32] and in the floating femurs [17] [34]. The clinical examination of the floating long bones demonstrates a “Z deformity”: a “Transverse Z” deformity for the clavicle and a “Sagittal Z” for the other longs

bones (arm, forearm, fingers, thigh, leg and foot).

4.4.2. Topography

The clavicle and the first metatarsal were clearly the most exposed bones in our study (**Table 1**) and in the literature [5] [33]. According to our knowledge, 45 floating clavicles and 17 floating first metatarsals were reported since Porral [9] and English [35]. The other floating bones were more exceptional. The explanation might be found in the mechanism and the joints stabilizers.

4.4.3. Complications

Associated fractures were common on the hip-joint [16], forearm [15] [27] [28] [29] and the tarsometatarsal joint [3] [6] [7] [8] [11].

All reported floating clavicle cases were displaced anteriorly at their sternoclavicular joint [1] [2] [3] [4] [5] [9] [33]. They did not represent any

Table 1. Reported cases of floating bones characteristics.

Bone	Sex	Age	Side	MOI	Displacements				Complications		Treatment		Immobilisation		Follow-up		Outcome
					Proximal end	Distal end	Proximal end	Distal end	Others	Proximal end	Distal end	Proximal end	Distal end	Proximal end	Distal end		
Clavicle	F	48	R	Axial loading (RTA)	Anterior	Posterior				ORIF (wires)	ORIF (wires)	Sling	24 months	Excellent	Excellent		
Clavicle	M	19	L	Fall (Sport)	Anterior	Posterior		Cutaneous thread		ORIF (wires)	ORIF (wires)	Sling	72 months	Excellent	Excellent		
Clavicle	F	40	R	Axial loading (RTA)	Anterior	Posterior			Thoracic contusion	ORIF (wires)	ORIF (wires)		15 months	Excellent	Excellent		
First metatarsal	M	25	L	Axial loading (RTA)	Superior (Dorsal)	Inferior (Dorsal MTPJ dislocation)		Open (plantar)		OR	OR	Plaster (3 weeks)	12 months	Excellent	Excellent		
First metatarsal	M	28	L	Axial loading (RTA)	Supero-medial	Lateral (Medial MTPJ dislocation)			Brain injury, M2 fracture	ORIF (wires)	OR	Plaster (8 weeks)	3 months	Excellent	Excellent		
First metatarsal	M	53	R	Heavy loading (WPA)	Supero-medial	Lateral (Medial MTPJ dislocation)		Open (medial)	Brain injury, M2 fracture	CR + PCF (wire)	OR	Plaster (3 weeks)	3 months	Excellent	Excellent		
Radius-Ulna	M	33	R	FFH	Posterior	Anterior (Dorsal RC dislocation)		Distal radius fracture		CR	Exofixation		5 months	Excellent	Fair		
Radius-Ulna-Lunatum	M	25	L	FFH	Posterior	Anterior (Dorsal PL dislocation)				CR	CR	Plaster (3 weeks)		Lost of view			
Femur	M	65	R	Axial loading (RTA)	Posterior	Anterior (Posterior knee dislocation)	Acetabular fracture	Cruciate ligament tears		CR	CR	Traction (3 weeks)	18 months	Fair	Poor		
First Metacarpal	M	43	L	Fall (WPA)	Posterior (Dorsal)	Anterior (Dorsal MCPJ dislocation)				ORIF (wires)	ORIF (wires)			Lost of view			
First Phalanx (Index finger)	M	30	L	Machine accident (WPA)	Posterior	Dorsal (Palmar PIPJ dislocation)	Open (Lateral)	Open (medial)		ORIF (wires)	OR	Splint		Lost of view			

mediastinal thread. Hand and foot dislocations are usually open dislocations [6] [12] [13] [22]. On extremities, the range of mobility is greater and the soft tissues around joints are fewer. It is commonly a skin opening from inside to outside (head of the first metatarsal). We found no post-operative complication. It is important to check pins and to remove them before six weeks.

4.4.4. Treatment and Outcome

First reported floating bones cases were treated conservatively [2] [4] [5] [9]. More recent authors preferred surgical management [3] [10] [11] [12] [13] [33]. We used more surgical management with good results. The advantage of surgical treatment is anatomic reduction, soft tissues stabilizers repairing, temporarily internal fixation and associated lesions management. The non-complicated floating humerus [18] [32], floating phalanx and floating femur [34] are exception of primary surgery.

5. Conclusion

The floating bone injury is still unknown and not well-described. Our study focused the nosology, the MOI, the clinical forms and the treatment of this double dislocation. It is important for any joint dislocation to check the other end of the dislocated bone to avoid missing a floating bone.

Conflict of Interests

The authors declare that they have no competing interests.

Consent

The patient and the families were informed that data from the case would be submitted for publication and provided their consent accordingly.

Author's Contributions

All the authors contributed of the writing of this manuscript and have read and approved the final version.

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