

# The term “floating” used in traumatic orthopedics

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## Abstract

**Background:** The term “floating” is used in orthopedic literature to describe certain patterns of skeletal injuries that share one common character which is disruption and discontinuity of bones above and below a joint. The first time used in orthopedic literature being in late 1970 to describe a type of elbow injury. Later the word was used increasingly and applied to a variety of injuries affecting the knee, shoulder, hip, forearm, hand, and ankle. Currently, there are about 12 different skeletal injuries described as floating.

**Objectives:** The aim of this article was to define the term “floating” used in traumatic orthopedics and to discuss its history, mechanism of injury in each region, treatment and outcomes based on the currently available literature. As there were many separate articles describing different sites of floating injuries, this review aimed to summarize all floating injuries into 1 article.

**Abbreviations:** CMC = carpo-metacarpal, K-wires = Kirschner wires, MCP = metacarpo-phalangeal, ORIF = open reduction and internal fixation.

**Keywords:** floating, ipsilateral fractures, traumatic orthopedics

## 1. Floating shoulder

### 1.1. Introduction

Ganz and Noesberger were the first to describe the loss of stability of shoulder when clavicular shaft fracture combined with the ipsilateral scapular neck fracture in 1975.<sup>[1]</sup> Subsequently, Goss expanded the definition into “double disruption of the superior shoulder suspensory complex” which is a bony and soft tissue ring consisting of the glenoid, corocoid process, coracoclavicular ligament, acromion, acromioclavicular ligament, and distal clavicle.<sup>[2]</sup> In 1992, Herscovici also defined the ipsilateral fractures of clavicular shaft and scapular neck as “floating shoulder.”<sup>[3]</sup> From then on, numerous authors reported the term “floating shoulder.”<sup>[4–7]</sup> These injuries are rare, Herscovici reported the incidence was 0.10% to 0.15% based on a review of 11,004 trauma patients within the 11-year period.<sup>[3]</sup> The mechanism of injury for the floating shoulder is typically a

high-energy trauma with more than 80% of the cases resulting from a traffic accident.<sup>[8–12]</sup>

### 1.2. Treatment

Since Ganz and his colleagues described this pattern of injury, there is a general consensus that floating shoulder is unstable in nature and at least some form of intervention is needed. Numerous treatment recommendations have been elucidated in the literature such as conservative management of both bones or internal fixation of the clavicle alone or fixing both the scapula and clavicle. But there are no clear indications for the amount of displacement needed to fix. Edwards reported excellent results in 17 out of 20 patients with floating shoulder treated with either a sling or shoulder immobilizer and recommended nonsurgical treatment for fractures with less than 5 mm displacement.<sup>[8]</sup> Ramos also reported good to excellent outcomes in 92% of 16 cases treated conservatively by using a Velpau bandage.<sup>[5]</sup> But they did not mention the displacement degree of the fractures. Herscovici reported that it is stable enough to achieve bony union of the 2 fractures when plating of the clavicle alone is performed and he strongly recommended open reduction and internal fixation (ORIF) of the clavicular fracture to prevent malunion of the glenoid neck.<sup>[3]</sup> While Leung reported that it is necessary to do ORIF of both the scapular and the clavicular fracture.<sup>[4]</sup> A multicenter retrospective study by Van Noort concluded that in the absence of inferior displacement of the glenoid neck, conservative management will result a good functional outcome.<sup>[10]</sup> A recent prospective study comparing conservative and operative treatment of floating shoulders found internal fixation of the clavicle gives a better functional outcome in the short term compared to conservative management.<sup>[13]</sup> Concerning the controversies in the outcome of different treatment options and the agreeability that unreduced fractures of the glenoid neck or significantly displaced clavicular fractures will result in a poor functional outcome, we recommend surgical intervention in all floating shoulder injuries with significant displacement in either the clavicle or scapula to improve the functional and clinical outcome. We believe further level 1 evidence research is needed to develop validated surgical indications and an optimal algorithm for the management of floating shoulder.

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## 2. Floating clavicle

### 2.1. Introduction

Simultaneous ipsilateral traumatic fracture dislocation of sternoclavicular and acromioclavicular joints are referred “floating clavicle,” although this is also referred as either bifocal clavicle dislocation, panclavicular dislocation or traumatic floating clavicle.<sup>[14,15]</sup> Porral was the first to report this injury in 1831.<sup>[16]</sup> Later in 1924, Beckman reviewed the previous literature and reported the results of 16 floating clavicles.<sup>[17]</sup> This injury is very rare and there are about 36 cases reported in the literature since 1831. The mechanism of injury in floating clavicle usually results from major trauma such as road traffic accident, falls from height, or direct heavy blow to the side of the shoulder.<sup>[17,18]</sup> Careful evaluation is necessary since plain x-rays may be inconclusive and specialized radiographic views will aid reach the diagnosis.<sup>[19]</sup>

### 2.2. Treatment

Currently, there is no agreed consensus on the treatment of floating clavicle but most authors advocate nonoperative management for low demand or asymptomatic cases without neurovascular injury and surgical treatment for those with higher functional demands, persistent pain or instability.<sup>[20–22]</sup>

## 3. Floating elbow

### 3.1. Introduction

Stanitski and Micheli firstly used the term “floating elbow” to describe ipsilateral humerus fracture combined with forearm fractures in children which dissociates the elbow from the rest of the limb in 1980.<sup>[23]</sup> Later, the term has been extended for the use of adults with concomitant humerus and forearm fractures in same limb and several authors have published reports on the characteristics, incidence, treatment, and outcomes of these injuries.<sup>[23–30]</sup> Recently the definition of floating elbow is not isolated only to ipsilateral diaphyseal fracture of humerus and forearm and there are some case reports and case series in which combinations of either extra-articular or intra-articular distal humerus fractures and proximal ulna fracture or fracture dislocations were described as floating elbow although these are mainly referred as “variants.”<sup>[31–35]</sup> Floating elbow injury is an uncommon fracture pattern in both children and adults<sup>[28,36]</sup> and the reported incidence is about 2% to 13%.<sup>[23,37]</sup> Most floating elbow injuries are resulting from high-velocity or high-energy trauma and motor vehicle accident and fall from height being the most common mechanism.<sup>[37,38]</sup> The incidence of associated injuries in the affected limb is high including soft tissue injury, neurovascular injury, and open fractures.<sup>[23,25,29,31,36]</sup> Identification and early appropriate management of these injuries are paramount since end results of the floating elbow can lead complications like malunion, nonunion, poor elbow function, elbow arthrodesis, and amputation.

### 3.2. Treatment

The management of isolated injuries to the humeral shaft, supracondylar region, the radius, and ulna have been clearly described in the literature but there are no guidelines for the treatment of combined injuries like the floating elbow. The treatment of floating elbow varies between adults and children. In the earliest reports in the English literature, these injuries in the

pediatric group where managed either with traction, casting or percutaneous pinning. In a case series of 15 patients, Reed treated all of them conservatively.<sup>[23]</sup> Other authors have used traction until soft tissue swelling subsided and performed delayed percutaneous pinning.<sup>[39]</sup> With the advances in understanding the mechanism and prognosis of the floating elbow, the strategies of management have changed and most authors advocate surgical treatment for both adults and children.<sup>[40]</sup> Some of the common conditions that necessitate the surgical treatment are the higher incidence of compartment syndrome thus making the use of plaster, conservative treatment contraindicated. The incidence of compartment syndrome is high 33% as reported by Blakemore in a case series of 33 children in which 3 among 9 children with displaced extension supracondylar humerus and displaced forearm fractures developed compartment syndrome.<sup>[41]</sup>

Although the reported incidence of compartment syndrome is high in the early researches, a recent retrospective studies show no compartment syndrome. Blumberg reviewed 47 children with supracondylar humeral fracture in which 21 of them had associated displaced forearm fracture; all the supracondylar fracture were managed surgically and all the forearm were immobilized with noncircumferential cast and none of those 21 children developed compartment syndrome.<sup>[42]</sup> Another recent retrospective review of 150 ipsilateral supracondylar humerus and forearm fractures did not identify any compartment syndrome in these children.<sup>[43]</sup> There is controversy in which fracture to fix first and whether to fix humeral fracture and to conservatively manage the forearm fracture but rigid stable fixation of all the fractures has been accepted as the best choice for the treatment of floating elbow injuries.<sup>[25,27,40]</sup> There is conflicting data regarding the results of conservative versus surgical treatment. One of the earliest studies of the floating elbow in adults was a retrospective case series of 19 patients aged between 17 to 57 years by Rogers found those treated with surgery did significantly better than those managed conservatively in regard to both bone healing and elbow range of motion.<sup>[25]</sup> In another retrospective study by Pierce of 21 patients showed no difference in the outcome of cases managed with traction, plaster immobilization, or open reduction.<sup>[44]</sup> This contradicts with the Roger study where he concluded that surgical management of both humerus and forearm fractures is superior to the conservative treatment. Several other investigators have also published results of review series among them Solomon who reviewed 18 patients with floating elbow managed surgically and there were no nonunion in all the patients.<sup>[45]</sup> In summary, though there is no specific type of surgical treatment with reliable excellent outcome, but stable external or internal fixation has been recognized as the most supreme method of management for floating elbow injuries in adults.<sup>[27]</sup> This very rare injury has unpredictable outcome based on which treatment method is used but several authors have reviewed prognostic factors on final clinical outcome. The most common factors related to worse functional outcome are concomitant radial nerve injury, intra-articular extension of the fracture, nonsurgical treatment of the injury and complications associated at the time of injury.<sup>[25,29,44–46]</sup>

In conclusion, floating elbow both in children and adults are rare injuries usually resulting from high energy trauma with unpredictable clinical outcome after treatment. A guideline on how to deal with these catastrophic injuries should be developed based on high-level evidence-based studies so the management and prognosis of the patients can be improved.

## 4. Floating knee

### 4.1. Introduction

It was 1965 when Blake and McBryde first described this pattern of injury defining as ipsilateral fracture of femoral shaft and tibia. McBryde and Blake also developed one of the commonly used classification systems for floating knee after a review of 51 patients with ipsilateral femur and tibia fractures.<sup>[47]</sup> The injury is usually caused by high energy trauma and 74% of these are associated with life-threatening conditions mainly head, chest, and abdomino-pelvic injuries and with a mortality rate of 5% to 15%.<sup>[48–50]</sup> Other associated injuries reported in the literature include soft tissue trauma, open fractures, contralateral extremity fractures, compartment syndrome, and vascular injuries.<sup>[50–52]</sup>

Several classification systems have been mentioned in the literature with each having its own limitations. The first were Blake and McBryde which classified floating knee injuries into 2 types: Type I is a diaphyseal fracture of the femur and tibia which may be simple or comminuted also referred as “true type” and Type II is a fracture with intra-articular extension also known as a “variant type.” Later in 1978 Fraser described another classification method in which type I is similar to the Blake and McBryde “true type” but subdivided type II into 3 components: Type IIa which accounts 8% is a femoral shaft fracture associated with tibial plateau fracture, Type IIb which accounts about 12% is an intra-articular distal femur fracture accompanied by tibial shaft fracture, Type IIc accounts 9% and is intra-articular distal femur fracture with a fracture of tibial plateau.<sup>[51,53]</sup>

### 4.2. Treatment

Since floating knee injuries are life-threatening conditions because of the associated multisystem injuries, careful and thorough examination of the whole patient is necessary and steps of advanced trauma life support examination should be carried out to detect and treat early in all associated injuries so that mortality can be decreased. The principle of life over the limb and to not cause further damage to the metabolically deranged patient should be kept in mind when deciding the treatment alternatives for floating knee injury.

In the past, several authors favored conservative treatment. In 1968 Omer reviewed a group of patients he treated either conservatively or operatively and concluded that conservative treatment of both bone fractures is safe, however, he noticed that the healing time for the operative group was 8 weeks earlier than the nonoperative group and also the functional outcome was not good in the conservative group.<sup>[54]</sup> Today, surgical treatment is generally recommended for floating knee injuries but there is no agreed single ideal technique.<sup>[55]</sup> Immediate definitive fixation is generally reserved for physiologically stable patients but damage control orthopedics and early total care should be applied to hemodynamically unstable patients. The surgical method and implant used should be based on the patient’s general condition, fracture pattern, location, associated soft tissue status, and available resources. It is worth noting to remind the reader that the currently available literature is limited on low-level quality evidence studies.

Retrograde nailing of the femur is the current advocated surgical technique for type I floating knee injuries except when the fracture is in the proximal third where antegrade nailing will be more suitable.<sup>[56–58]</sup> Theodoratus recommended intramedullary nailing of both fractures except for open type IIIB and C fracture as nailing in open femur fracture was found to be a risk factor for infection.<sup>[59,60]</sup> Nailing of the femur is recommended

first to allow easy mobilization, removal of traction, and access to the tibial shaft fracture.<sup>[53,56]</sup> Several authors recommended single incision technique for nailing both femur and tibia.<sup>[53,56,61]</sup> One of these authors, Rios found that single incision technique has less operative and anesthetic time as well as reduced blood loss.<sup>[57]</sup> Some other researchers found increased incidence of complications like fat embolism syndrome when both fractures were managed with reamed intramedullary nail.<sup>[62]</sup> The recommended treatment method for fractures involving either the articular surface of femur or tibia is plating and the principle of anatomic reduction for the articular fragments should be followed. Also when there is intraarticular involvement of both bones like type IIc Fraser classification, plating is recommended for both bones.<sup>[51,63,64]</sup>

Floating knee injuries are associated with high complication rates especially in certain types of fractures which are associated with poor outcome; among them are intra-articular involvement of the fracture, severe bony comminution and soft tissue injury, vascular injury, open fractures, and higher injury severity score.<sup>[58,63,65,66]</sup>

In conclusion, floating injury of the knee is a serious injury that need to be managed aggressively to decrease morbidity and mortality associated with it. The patient should be treated as a whole, prioritizing associated life-threatening conditions and applying principles of damage control orthopedics in the unstable patient. The goal should be to save the patient and stabilize the limb to achieve the best possible functional outcome. Associated complications like fat embolism syndrome, compartment syndrome, ligamentary injury should be identified early, addressed promptly and specifically.

## 5. Floating hip

### 5.1. Introduction

The use of the term floating in hip injuries dates back in 1992 with Liebergall case series of 17 patients with ipsilateral femoral fractures associated with acetabular or pelvic fractures.<sup>[67]</sup> Liebergall himself and several other authors used the term to describe similar injuries but interestingly Müller described similar pattern of injury but disagreed to use the term “floating hip,” arguing that this description is imprecise and misleading.<sup>[68–70]</sup> It is worth to mention that Tile reported a case report in 1984 with ipsilateral femur and pelvic fractures.<sup>[69]</sup> Several other authors have also published case reports of the same injury before Liebergall but none of them used the term floating hip to describe their injury.<sup>[71,72]</sup>

The mechanism of injury is usually a result of high energy trauma such as road traffic accidents and falls from height while the reported incidence in the literature is estimated about 1:10,000 fractures.<sup>[67,73]</sup>

This combination of rare injury is usually classified into 2 types: Type A is fracture of the pelvic ring and ipsilateral femur and Type B is ipsilateral fracture of the acetabulum and femur.<sup>[67]</sup> A number of associated injuries have been reported in the literature including visceral organ injuries, extremity fractures, and neurologic injury.<sup>[67,74]</sup>

### 5.2. Treatment

Unlike floating knee and elbow injuries, the treatment options for floating hip injuries are limited to several papers of case reviews and reports.<sup>[67,69–73]</sup> But here we summarize what the different authors reported in their reviews; Liebergall stated operative fixation of all

components is necessary and he recommended internal fixation of the femur first followed by the acetabulum or pelvic ring as this will make the reduction of the acetabulum easier. Traction can also be applied on the femur once stabilized to reduce pelvic and acetabular fractures.<sup>[67,74]</sup> Kregor and Templeman opposed and suggested that initial fixation of the acetabulum before the femur is important to prevent further damage to the hip.<sup>[75]</sup> Wu described that early internal fixation of the femur with either external or internal fixation of the unstable pelvic injury was his preferred treatment method in 23 adult patients with type B floating hip injuries.<sup>[76]</sup> Regardless of which component to be fixed first, the patient's associated injuries, as well as hemodynamic stability, should be considered and once the patient is ready to tolerate the further injury from the surgery should undergo definitive fixation. It is recommended by some authors that a single incision is approached when fixing the acetabulum and femur fractures to minimize trauma to the patient.<sup>[67]</sup> The details of the surgical management of each fracture are beyond the scope of this review.

## 6. Floating arm

### 6.1. Introduction

Güven was the first to use the term “floating arm” to describe a combination of ipsilateral proximal humerus and supracondylar fracture in a 10-year-old boy.<sup>[77]</sup> Though 2 similar patterns of injuries were reported in the literature before him but none of them used the term.<sup>[78,79]</sup> The mechanism of injury is usually a high energy trauma like motor vehicle accident or falls from height.<sup>[77,80,81]</sup>

### 6.2. Treatment

Regarding the management of floating arm injuries, both operative and nonoperative treatment methods have been reported. Themistocleus treated an 80-year-old woman with floating arm conservatively with good results.<sup>[82]</sup> Some authors recommend surgical treatment.<sup>[77]</sup> Güven advised to fix the supracondylar fracture first by using a joystick method followed by fixation of the proximal humerus fracture.<sup>[77]</sup> It is important to consider patient's age, health status, and activity level when deciding which treatment method to choose.

## 7. Floating forearm

### 7.1. Introduction

Several descriptive injury patterns have been used to define ipsilateral injuries to elbow and wrist. The most common of these are floating forearm and bipolar dislocation of forearm. This is an ipsilateral dislocation of elbow with perilunate fracture dislocation and they are very rare injuries usually resulting from high energy trauma.<sup>[83,84]</sup> Several authors have published case reports on these injuries. Chen was among the first to report and he concluded that closed reduction of the elbow dislocation and early surgical fixation of the perilunate fracture dislocation will lead to satisfactory results in these patients. Currently, there are about 13 cases of floating forearm injuries published in the literature, though there is some variations in specific injury characteristics of these patients.

### 7.2. Treatment

Overall, floating forearm injuries should be managed urgently by closed reduction of the elbow dislocation and operative fixation of the perilunate fracture dislocation to achieve the optimal functional outcome.<sup>[85]</sup>

## 8. Floating radius

### 8.1. Introduction

This is one of the rare terms used to describe an injury and there are only 2 articles describing this pattern of injury. Simpson and Jupiter gave multiple definitions to floating radius including: ipsilateral simultaneous Monteggia and Galeazzi fracture dislocation, combination of proximal third ulna fracture dislocation with or without radial head fracture associated with distal radius fracture and distal radioulnar joint dislocation.<sup>[27]</sup>

Preziosi reported a case of floating radius in 2006. This was a 33-year-old man with a combination of radial dislocation both at elbow and wrist with no radial head fracture. The mechanism of injury for this patient was fall into an outstretched hand.<sup>[86]</sup>

### 8.2. Treatment

Owing to the rarity of this type of injury, there is no enough data to conclude the best management. But prompt diagnosis and early treatment would most likely result satisfactory results.

## 9. Floating metacarpal

### 9.1. Introduction

In the literature, this injury is most commonly applied to index, thumb and fifth metacarpal although it is also used in other metacarpals. Two definitions have been used to describe floating metacarpals. Rex defined as simultaneous dislocation of metacarpo-phalangeal (MCP) and carpo-metacarpal (CMC) joint of the index finger as floating metacarpal.<sup>[87]</sup> Jackson in his case report defined the injury as fracture dislocation of the head and base of the index metacarpal.<sup>[88]</sup> The proposed mechanism of injury for floating metacarpal is hyperextension of MCP joint with flexion of CMC joint.

### 9.2. Treatment

Management of this injury can either be operative or nonoperative and there are reports with good outcome in each method.<sup>[88,89]</sup>

## 10. Floating fibula

### 10.1. Introduction

A simultaneous disruption of both proximal and distal tibiofibular syndesmosis is referred as floating fibula.<sup>[90]</sup> Hugh was the first to use the term in a case report in 2008. The patient was injured in a motor vehicle accident and they have fixed with tightrope sutures in both joints.<sup>[90]</sup>

### 10.2. Treatment

Generally screw fixation is most commonly used for distal tibiofibular stabilization<sup>[91]</sup>; however proximal syndesmotomy diastasis should be managed with accurate reduction followed by casting or stabilization with Kirschner wires (K-wires), cancellous screws, or bioabsorbable sutures.<sup>[92,93]</sup>

## 11. Floating ankle

### 11.1. Introduction

McHale first defined this injury as an intact ankle mortise combined with distal tibia fracture and ipsilateral foot fracture in their review of 4 military personnel in 2001.<sup>[94]</sup> The mechanism is

usually from a violent trauma such as blast or blast like injuries. When these injuries affect civilians, it is either due to fall from considerable height or motorcycle accidents. McHale found the fracture of the tibia occurred at the boot top perhaps the footwear absorbs the energy thus protecting the ankle joint but transmits the force to the unprotected tibia resulting in tibia fracture.<sup>[94,95]</sup>

## 11.2. Treatment

Management of this injury can be salvage or amputation depending on the extent of the injury and age of the patient. Salvage is usually preferred for the young patient with an attempt to restore the anatomy of the ankle and foot.<sup>[96]</sup> Salvage options include external fixation alone or external fixation augmented with internal fixation, ORIF. Although there are several scoring parameters to aid amputation versus salvage, each has its own limitations so well executed prospective studies are needed to define which injuries to be salvaged and which to be amputated.

## 12. Floating metatarsal

### 12.1. Introduction

Simultaneous dislocation of the metatarsal bone from its proximal and distal articulations is referred as floating metatarsal. Leibner first described the term in 1997 and later on several case reports with similar injury patterns have been published.<sup>[97–100]</sup> The mechanism of injury is usually an axial compression.

### 12.2. Treatment

The management of this injury depends on whether it is an isolated injury or accompanied by ligamentous disruptions. K-wire fixation is usually adequate to stabilize the fracture if there is no ligamentous injury.<sup>[97–100]</sup>

## Author contributions

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