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Does Fracture Classification Work all the Time? Dilemma Persists!

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Introduction

The site of injury is not just injury per se rather it's like a "crime scene investigation," where every single detail and information holds paramount importance. We have divided our observations into four basic principles for quick assessment; how it occurred (mechanism), to whom it occurs (child/adult/elderly), the severity of the damage done (energy of injury and its consequences) and what next to expect (complications). In addition, there are several compounding factors which we shall be discussing in our article affecting our plan of treatment. The concept of classifying fractures is based on the fact that it should guide in actual fracture management protocol which should be universally applicable and universally acceptable. Currently, certain fractures classification is just mere understanding of the fracture patterns rather than indentifying various factors which affect the final outcome in terms of biological and functional outcome. The fracture fixation should take into anatomical, biological and biomechanical consideration before attempting to classify to define its plan of management. Recent literature, there is lack of evidence based medicine in terms of final outcome for certain fractures of our concern, for example injuries like floating knee. To the best of our knowledge, there is no classification among these injuries which really determines the plan of management. In this particular article, We tried to evaluate the demerits of the classification by reviewing the literature for existing classification of floating knee. We have proposed new classification methodology for better, comprehensive classification to plan our management after thorough literature review regarding the factors affecting the initial plan of management. Irrespective of the type fracture involving any segment of the bone there are certain factors which guide us to the understanding the damage done and may applicable to all types of fractures as suggested by OTA group in attempt to classify a new classification for open fractures [1].

Floating Knee is the term applied to the flail knee joint segment resulting from a fracture of the shaft or adjacent metaphysis of the ipsilateral femur and tibia [2]. This term coined by McBryde and

Blake has also been used to describe the separation of knee joint is either isolated partially or completely due to fracture of the femur and tibia [3,4]. The associated injuries and the type of fracture (open, intra-articular, comminution) are prognostic indicators of the initial and final outcome in patients. Finally, variants of these injuries as suggested by McBryde et al. are also necessary, in changing surgical preoperative planning [3,4]. A word of caution should be made here regarding the patient selection. Based on the present classification by McBryde et al. and Fraser et al. , it's not possible to decide on the patient selection and optimal timing for surgical intervention [3,5]. Local needs also need to be addressed keeping in mind the infrastructure available at that particular centre. Such high velocity injuries are associated with significant soft tissue injury, sometimes even leading to amputations [6,7] and even life threatening scenario [5,7]. However, assessment of other associated injuries for example, knee ligament injury should be done to plan post-operative rehabilitation for a good final outcome Orthopaedic surgeons typically recommend various treatment regimens, especially aggressive and early stabilization of both femoral and tibia fractures [8,9]. Some authors have reported that the complication and mortality rates remain high regardless of the treatment regimen used [10].

Epidemiology and Etiology

The exact incidence of the floating knee is not known, it is an uncommon injury. The commonest most of injury is road traffic accidents especially in automobile passengers with their feet firmly braced against the sloping floor of the front seat just prior to collision [11]. Other modes described in literature are fall from height [12]. The largest series reported in the literature was of 222 patients over 11 years [6]. Increase frequency of this severe injury is probably due to increase in high speed traffic every year. A male preponderance is observed, particularly in young adults 20-30 years of age. Other mechanisms are gunshot wounds and falls from heights as mentioned above where age or gender preponderance is still not known. Such combination of fractures is less common in the pediatric population than in adults. However, epiphyseal involvement can adversely affect open growth plates, predisposing a child to limb-length discrepancy and angular deformities.

Floating knee injuries must be included in assessment and treatment protocols for patients with polytrauma based on ATLS protocol [13]. Neurovascular damage (mainly the popliteal and posterior tibial arteries, peroneal nerve) is common. Vascular injury is common along with impending or established compartment syndromes and may be life threatening if not recognized and addressed. Often, the vascular injury is to the anterior tibial artery which does not result in ischemia and need not be treated with vascular repair or reconstruction. Traction neurapraxia, which often resolves, but complete recovery is not always the rule. The major concern is the incidence of open fractures which is as high as 50-70%, at one or both fracture sites. The most common combination is a closed femoral fracture with an open tibial fracture due the lack enough soft tissue and muscular coverage on the proximal tibia anteriorly. Injury to the knee ligaments that occur in association with ipsilateral femoral and tibial fractures is a known entity, commonly the anterolateral rotatory instability. Due to joint swelling mistaken for sympathetic effusion, knee ligament injury is not always suspected due to hemarthrosis and can be missed. Until proven, all these injuries should be evaluated for ligamentous injuries [14]. In skeletally immature patients, floating knee is uncommon. Few studies of this injury have been conducted in children [15,16]. Findings observed in children are comparable to those in adults in terms of the mechanism of fracture, the incidence of associated major injuries but the treatment pattern may not be on the same line as adults. Epiphyseal injuries in growing child have even bigger implications. In children, especially those younger than 10 years, treatment of ipsilateral femoral and tibial fractures is controversial. In adults, all floating knee injuries must be addressed with early anatomic reconstruction and stable

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surgical stabilization of both fractures. The goal is to allow for early joint mobilization and better functional outcome.

Classification of Fracture in adults

Two classifications, to the best of our knowledge exist each in adults and pediatric cohorts of patients (Tables 1and 2).

In both classification systems described above, type II fractures with intra-articular involvement have been linked with higher complication rates and poorer functional results than those observed with type I injuries. Unfortunately, the classification does not take into account regarding open or closed associated injuries, neurovascular status, associated fractures, variants of the injury and soft tissue condition which aid in surgical planning learned from our clinical experience. Surgical planning cannot be based merely on the fracture pattern rather the above mentioned parameters may majority of the times play bigger role in deciding primary versus delayed fixation of these fractures. In addition, none of these classifications describe the level of fracture for shaft, degree of comminution; certain floating injuries described even for soft tissue injuries for example "floating meniscal injuries," which have emphasized the clinical relevance of these missed tears. We reviewed the literature, but did not come up any evidence that these classifications actually aided or guided patient selection based on either of the above classification. Associated injuries have been emphasized in most of the series in literature, [3-10,17,18] but none actually included those parameters while classifying and planning their management based on them. However, the criteria Karlström and Olerud established are widely accepted for evaluating functional outcomes in these injuries [19]. In addition, none of the classification mentions whether these fractures were open or closed. Similarly, in children, floating knee injuries are classified according to the Bohn–Durbin or Letts classification systems. In the Bohn–Durbin classification, [15] floating knee injuries are classified as follows:

Type I - Double-shaft pattern of fracture

Type II - Juxta-articular pattern

Type III - Epiphyseal

Again, the Bohn–Durbin classification does not account for open fractures and cannot be used to predict complications and prognosis. A modified Bohn-Durbin classification by Hüseyin, concluded that knee ligament injuries do not affect the outcome of floating knee trauma in children, although they do in adults. Open knee injuries do affect the outcome, and operative treatment of the femoral fracture is the treatment of choice for all ages. Letts et al. designed a new classification system in which they classified into diaphyseal, metaphyseal or epiphyseal knee fractures (type A/B/C) and also open fractures (types D and E) [16]. The drawback of their classification system is that they do not indicate how to classify patients with epiphyseal separation in distal femur and tibia or how to describe the location of open fractures in the epiphysis, metaphysis or diaphysis [16].

Type 1 – True Floating Knee with either shaft fractured.	The knee joint is isolated completely and not involved,
Type 2 – Variant Floating knee	Involves one or more joints with either shaft fractured.
Type 2A	The knee joint alone is involved
Type 2B	involves the hip or ankle joints

Table 1: Blake and McBryde classification for Floating Knee injuries.

Type I: Type 1 is the same as the true injury Blake and McBryde described with extra-articular fractures of both bones [3, 4]. Type II is subdivided into 3 groups, as follows:
Type II A: Type 2a involves femoral shaft and tibial plateau fractures.
Type II B: Type 2b includes fractures of the distal femur and the shaft of the tibia.
Type II C: Type 2c indicates fractures of the distal femur and tibial plateau.

Table 2: Fraser et al. classification of floating knee injuries in a similar way by analyzing knee involvement [5].

The New Classification Proposed Is Based On: Based On: 10 Different Parameters

1. Location of Fracture in Bone.
2. Intrarticular Involvement.
3. Associated Fractures and Variants (Including Ipsilateral Hip and Ankle Injuries).
4. Bone Defect.
5. Soft Tisssue Injury.
6. Open or Closed #.
7. Neurovascular Deficit.
8. Co-Morbids /Lung Injury (ARDS or Acute Lung Injury).
9. Abdominal injury/vascular/thoracic injuries.
10. Fat embolism.

The classification has been assigned three different letters.

E.g.AAA: 1st letter denotes femur; second letter denotes knee third letter denotes fibula and finally fourth denotes the W/X/Y/Z.

Type 1ACC+ denotes: extra articular fracture of distal third femur with extra articular fracture proximal third tibia with proximal fibula with open injury.

A/B/C- Location of Fracture for shaft injuries.

A-Distal One Third

B-Middle One Third

C-Proximal One Third

D-Any of the above patterns with variants

E/F/G- Based On Intrarticular/Comminuted/bone defect.

Level of Fibula # A/B/C as Above.

W-Open versus Closed Injury

X-Soft Tissue Injury Present/Absent

Y- Neurovascular Deficit Present/Absent

Z- Comorbids Or Lung Injury (ARDS/Acute Lung Injury-Ali) Present/Absent

Soft Tissue Injury- E.g. Patella Tendon Rupture Other Ligamentous Disruption

1– Both Shaft Femur & Tibia

2– Femur Shaft With Intra-Articular Proximal Tibia

3– Femur Intra-Articular With Tibia Shaft

4– Both Intra-Articular

5– Any of the above with associated injuries.

Type 1:

A-Distal One Third

B-Middle One Third

C-Proximal One Third

D- Any of the Above With Variants

Type 2:

Femur Shaft with Intra-Articular Proximal Tibia

For Shaft –A/B/C/D articular fracture: E/F/G

E-Intra-Articular, Uncomminuted

F-Communited #.

G-Comminuted # with Bone Defect.

Type 3:

Femur Intra-Articular With Shaft Tibia

Shaft –A/B/C/D

E-Intra-Articular, Uncomminuted

F-Communited #,

G-Comminuted # with Bone Defect

Type 4: Both Intra-Articular

E-Intra-Articular, Uncomminuted

F-Communited #,

G-Comminuted #, with Bone Defect

Type 5: Any of the above with presence of any of these five factors:

1. Presence Abdominal injury
2. Significant Head injury
3. Significant Thoracic injury/neck injuries
4. Significant Upper limb fractures
5. Presence of Fat embolism

Distal femur fractures have been: Sub-Classified Into:

Coronal #/ Saggital #/In All Planes

1. Coronal 2.saggital 3.fracture can be visualised in all planes.

The investigations proposed are:

1. Antero-Posterior Views & Lateral Radiographs For Femur And Tibia With Joint Above And Below.
2. Pelvis with Both Hip-Anteroposterior Views
3. Additional Views: Oblique Views if CT not possible then it is mandatory.
4. CT- In Selected Cases
5. MRI: Selected Cases If Indicated
6. Hand held Doppler in all cases.

Discussion

Floating knee injuries are caused by high energy trauma which in which patients sustain significant and occasionally life threatening associated injuries [20]. Associated injuries like head, chest, abdominal injuries and injuries to other extremities, head injury, chest and abdominal injury can be life threatening [21]. Currently the, reported mortality rate ranged from 5–15% reflecting the impact of associated in the floating knee [22]. There is a higher incidence of neurovascular and soft tissue injury in this injury. Extensive literature has been published in surgical stabilisation of both fractures in the floating knee and established that early stabilisation of fracture have the best outcome results [23]. Unfortunately, no classification till date includes any of these parameters while deciding the plan of management. Due consequence of high velocity trauma, certain injuries take priority over the fracture fixation which have a significant role in surgical decision making with regards to timing of surgery and sequence of surgery. Significant abdominal injuries take priority over surgical stabilisation of the fractures. None the present classification mention how the management changes in presence of these grave injuries. Assessment of suspected abdominal injuries should be by clinical assessment and ultrasonography and urgent CT if there was a suspicion of intra-abdominal injury. Along with any associated medical co-morbidities which can worsen the already compromised physiologic reserve especially in the elderly. Another associated injury is significant head injury. There is no data in the literature that the injured brain is at risk for further injury during the surgical procedure provided the patient is not exposed to hypotension and hypoxia. The only reason of delay in surgery is a patient with a fluctuating Glasgow Coma scale [21]. All patients with fluctuating conscious levels need a CT scan of the brain. An intracranial haematoma or bleed is diagnosed these patients needs neurosurgical intervention unit for further management. Poole GV et al. found that surgical stabilisation of fractures within 24 hours of injury reduced the risk of pulmonary complications (fat embolism, pneumonia and adult respiratory distress syndrome), in their comparative study on lower extremity fracture fixation in patients with head injury[23,24]. Cerebral injuries have been found to be associated with high risk of pulmonary complications [25]. A delay in fracture fixation did not protect the injured brain. The next associated injury is vascular insult which is of paramount importance and surprisingly none of the present classification has laid down comprehensive treatment plan. Cakir et al. fractures recommended careful assessment of the peripheral pulses by palpation or hand held Doppler [26]. We recommend routine use this equipment and documentation during assessment for presence of vascular injury. This can further extended to preoperative angiogram if an arterial injury is suspected provided was no critical ischaemia to the limb is present and associated injuries are not a constraint. Vascular surgeon opinion with an on table angiogram is ideal .The general consensus is that bone stabilisation should precede vascular repair in unstable fractures while in stable fractures vascular repair should be done first to avoid prolonged ischaemia to the limb. Controversy exits over the sequence of surgical vascular repair and bone stabilisation [26-30]. McHenry et al. concluded that no iatrogenic disruption of the vascular repair occurs when bone stabilisation followed vascular repair [31]. Floating knee is an unstable injury and manipulation of the fracture after repair of a vessel can put stress on the repair leading to failure of the repair since they poor prognosis. Early fracture stabilisation of fractures is associated with significant reduction in pulmonary complications such as fat embolism, pneumonia and Adult Respiratory Distress Syndrome [32,33]. As mentioned earlier, the plan of management plan differs when we take in to account as to whom injury affects. Elderly have diminished physiologic reserve and pre-existing co-morbid conditions may contribute to higher morbidity and mortality following a floating knee injury. The principle here is to manage the patient's co-morbidities

(cardio-respiratory, renal etc) till the patient is fit to undergo surgery to improve the patient's final outcome [34,35]. Besides these complex situations, the current classification has no mention about these variable accounting for change in plan of delayed versus primary fixation. It is still the one the biggest diagnostic dilemma is associated ipsilateral knee ligament injuries which are often missed [7,22,36]. Appropriate management of the knee ligament injury is essential for a good outcome after treatment of the floating knee and better range of movement [31]. Szalay et al. in their study of 34 floating knees found detectable ligament laxity in 53% [36]. Clinical tests for example Lachmann test is almost 100% diagnostic of anterior cruciate ligament tear when performed under anaesthesia [31,37]. Surgical stabilisation of the fracture, stress testing of knee ligaments, acute arthroscopy and ligament acute repair of knee ligaments has been suggested by few studies [38]. Arthroscopy seems to better option in avoiding the need for MRI assessment and gives therapeutic option in the patient who may be haemodynamically unstable.MRI still is the gold standard for stable patients. After surgical stabilisation, interference artefacts from the metal work, preventing proper visualisation of the knee ligaments are another issue [39]. We feel that a clinical assessment under anaesthesia followed by a diagnostic arthroscopy is the best method of assessment of ligament injuries in these cohorts of patients. Current classifications have no mention about the treatment options of floating knee with these associated injuries. There is no evidence in literature regarding the impact of associated injuries on the treatment of floating knee except by retrospective study by Rethnam et al [13]. Other associated injuries, equally important are neck injuries, chest injuries; associated upper limb injuries and fat embolism have no mention the present available classification. Rethnam et al. concluded that fat embolism and fracture clavicle did not lead to delay in rehabilitation [13]. Chest injuries, fracture clavicle also did not have impact on final outcome [13]. Contralateral femur or tibia also did not have influence in the final outcome [13]. Rethnam et al also concluded that delay in surgery in patients with head injury and fat embolism did not have impact on functional outcome [13]. Ipsilateral knee injuries((Patella fractures, cruciate ligament injuries) and upper limb fractures (humerus and forearm) tended to have an increased delay in rehabilitation as compared to patients with contralateral lower limb fractures (tibia, femur) and those with chest injuries (rib fractures, haemo-pnemothorax). Limitation of this study was that it was a retrospective design with small sample size. However, we believe that associated injuries which may not have impact on the final outcome still are significant in deciding the initial plan of management. We have tried to incorporate those factors which help in deciding which one can be primarily fixed and which one could wait till they deemed fit to operate upon. Impact of these injuries in children is and surgical management of these injuries beyond the scope of this article.

Floating knee injury is like "tip of an iceberg" with complex presentation. Some associated injuries are still diagnostic dilemma. Currently; there is no comprehensive classification to address these issues. New proposed classification proposed in this article is a comprehensive classification to plan our management and to improve functional outcome among these injuries by taking into account of the associated injuries. However, new proposed classification awaits clinical correlation.

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