ORIGINAL RESEARCH

PATELLA FRACTURES: A REVIEW OF CURRENT MANAGEMENT

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Diamond Tamunokuro Ezekiel

Department of Surgery, Faculty of Clinical Sciences, College of Health Sciences, University of Port Harcourt, Nigeria

Correspondence: Diamond, T,E **Email:** teddymond@gmail.com

Abstract

Introduction: Patella fractures are not commonly encountered in orthopaedic practice constituting only 1% of all bone fractures. Because of its key role in the knee's extensor mechanism, fractures affect ambulation negatively. Non- operative treatment is reserved for un-displaced fractures. Surgical treatment options are fast evolving driven by the need to provide more stable and less irritative constructs. The aim was to highlight the current concepts in the clinical diagnosis of patella fractures and discuss the available evidence that can guide current clinical practice.

Methodology: This is a narrative review that discusses relevant studies on patella fractures with emphasis on treatment options, their strengths and weaknesses.

Results: The single most common operative treatment for displaced transverse patella fractures is tension band wiring (TBW). Though favourable outcomes have been reported, irritation of the soft tissue by the subcutaneous implant, wire migration and frequent need for early implant removal are major drawbacks. TWB is also not suitable for comminuted and polar fractures. Newer implants have shown excellent results with comminuted and polar fractures and are less irritative than TBW. The indications for partial or total patellectomy are fast reducing, stimulating the need for more research on patella fractures.

Conclusion: Appropriate patient counselling guided by the severity of the injury, the pattern of fracture, pre-injury status, state of the extensor apparatus, available resources, local soft tissue condition and the patient's preferences are key to successful outcome.

Key words: Patella fractures, Current concepts, Management

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INTRODUCTION

The patella bone is the largest sesamoid bone in the body.[1] It is a saucer-shaped bone located in front of the knee between the fibers of the quadriceps tendon and the patella tendon serving as a key component of the extensor mechanism of the knee. Its concave articular surface articulates with the articular surface of the distal femur to form the patello-femoral joint while the convex subcutaneous anterior surface provide attachment to the quadriceps tendon superiorly and the patella tendon inferiorly.

Patella fractures make up 1% of all bone fractures.[2] The most common mechanism for closed fractures are direct blows to the patella[3] (from dashboard injuries, falls on a flexed knee, external brutal forces on the knee). Eccentric contraction of the quadriceps with sudden knee knee-flexion and penetrating trauma have also been implicated.[3,4,5] Open patella fractures are rare constituting less than 8% of all patella fractures and usually connotes high energy impact with associated fractures of other bones within the region and injuries to other organs.[6,7] These injuries constitute huge management challenges.

More recently periprosthetic fractures from total knee replacement surgeries have made increasing contributions to the prevalence of patella fractures.[8] As the number of total knee replacement surgeries are projected to increase to over 3 million yearly surgeries by the next decade[5], the incidence of these fractures occurring in a prosthetic knee is also expected to increase, creating management difficulties to both the trauma and arthroplasty practices. These difficulties typically arise from the smaller than anatomic size of the remnant patella, the atypical fracture patterns, the possible need for repeat surgery as well as the background osteoporosis.

Tension band wiring with use of stainless steel Kirshner wires and cerclage wires placed in a figure -of-8 configuration remain the most common surgical treatment for transverse patella fractures. Hardware irritation, frequent request for early implant removal and implant failure have been reported as its major drawbacks[9,10]. Cannulated screw fixation and suture fixations reduced the incidence of hhardwaresymptoms but union rates are not superior to traditional methods. Fractures around the poles and stellate fractures are inherently unsuitable for these methods of fixation. The use of plates been reported to have superior fracture stability and less post-operative fracture displacement for these fracture patterns. Plate fixation however requires special plates that are not commonly available in low-income countries and carries the risk of encroaching the articular surface leading to early patella-femoral arthritis.

This paper aims to highlight the current concepts in the clinical diagnosis of patella fractures and discuss the available evidence that can guide current clinical practice.

MATERIALS AND METHODS

This is a narrative article on patella fractures with emphasis on treatment options, their strengths and weaknesses.

RESULTS AND DISCUSSION

Anatomy

The patella bone embryologically developed as a sesamoid bone within the quadriceps tendon with single ossification centre appearing at 2-6 years of age and completing at puberty.[11] A secondary ossification centre usually at the superior-lateral edge of the patella may refuse to fuse in a small percentage of the population giving rise to a bipartite patella which may be mistaken for a superior pole fracture. In 50% of cases this condition may be bilateral.

The patella is the largest sesamoid bone in the body, mainly subcutaneous and located in front of the knee joint. its anterior surface is mainly subcutaneous and provides attachment to the quadriceps tendon superiorly and the patella tendon inferiorly. The continuum of the quadriceps muscles, the quadriceps tendon, the patella and the patella tendon make up the extensor mechanism.

The posterior surface has medial and lateral surfaces (articulating with the respective articular surfaces on the anterior femur) separated by a median ridge that articulates with the femoral trochlea in deep knee flexion.[12,13] Lou et al[14] reported that the articular layer of the patella is the thickest articular layer in the body. This perhaps explain the vulnerability of the remnant patella to fractures when

the articular surface is replaced in total knee replacement surgeries.

Functionally the patella bone protects the knee joint, provides attachment to the quadriceps and patella tendons and serves as a fulcrum to improve the efficiency of the extensor mechanism of the knee. This latter function is aided by the patella retinaculum which is formed by the fibers of the vastus medialis and quadriceps aponeurosis medially and the vastus lateralis and facia lata laterally.

The patella receives blood supply in a centripetal manner with sources from the medial and lateral geniculate arteries and the nutrient arterial at the inferior pole ensuring rich supply to the bone.[15]

The patella's thoroughly subcutaneous anterior surface creates lots of irritation to anteriorly placed metallic implants used for fracture fixation and necessitating frequent implant removal for tradition fixation methods.

Epidemiology

One percent of all bone fractures are patella fractures[16]. The reported peak ages differ. Kruase et al[17] in observational study from a Swedish registry involving 3194 patella fractures reported a median age of 67years (range 19–100 years). Larsen et al[18] from a retrospective study in Denmark involving 756 patellar fractures, however reported a mean age of 54years. Zelewski *et al*[19] in Germany on the other-hand reported peak incidence among the 20-50years age group. What has showed consistency among reports is the sex predominance with many workers [18,20,21]reporting higher incidence among elderly female probably indicating a close link with osteoporosis. The reported incidence varies from 5.0-13.1 fractures per 100,000 population per year.[17,18,19]

The etiologic factor for patella fractures varies with age, sex and other population demographic fractures. Kruase et al.[17] have reported simple falls as the most commonly implicated cause of fractures in 70% of cases with road traffic accidents accounting for less that 25%. The predominantly elderly female population of their study explains this finding. This is similar to findings from Larsen et al[18] in a Denmark. Both demographics are similar. Bostrom et al[22] have however reported more direct high energy trauma to the knee which is more common in younger males.

Peri -prosthetic patellar fractures

Patella fractures are fast becoming the most common iatrogenic fractures since the advent of total knee arthroplasty. Kurtz et al[23] have projected that total knee arthroplasty will grow by 673% between 2005 to 2030 with an anticipated demand for 3.48 million surgeries by 2030. The incidence of peri-prosthetic fractures is also expected to grow with this projection. Currently the incidence of periprosthetic fractures are reported to be between 0.5-1.5% for primary total knee replacements and 1.2-2.5% for revision arthroplasties.[23,24] Berry and rand[25] reported that revision arthroplasties with patellar component substitution has twice the rate of postoperative periprosthetic patella fracture (1.8%) and nine times the rate of intraoperative patella fracture (0.2%) compared to primary total knee arthroplasty. Typically, these fractures occur either intra-operatively or post-operatively with the latter being more common than the former.[26] More than necessary force applied to the patella clamp, restricted surgical access, excessive retraction of the patella especially when everted, perforation of the remnant patella during preparation, overzealous patella cuts with <10mm of remaining bone stock, thermal necrosis from cementing and poor bone stock have all been implicated in intra-operative patellar fractures.[27]

Post-operative peri-prosthetic fractures on the other hand can be caused by trauma or atraumatic events. Traumatic fractures have similar etiology with native patella fractures but pose a more difficult management challenge. Reported factors in the etiology of atraumatic peri-prosthetic fractures include, patella maltracking, remnant patella bone stock less than 10mm, patella revision, injury to the superior lateral geniculate artery usually from a lateral release, overstuffing of the patello-femoral joint from non-optimal implant placement, implant choice (especially implants with large central pegs and those with metal base

plates) as well as loosing of a previously well positioned implant.[28,29,30]

Male gender, increased activity and osteoporosis are patient-related factors that can cause peri-prosthetic fractures. Peri-prosthetic fractures generally create treatment challenges and should best be avoided.

Fracture classification

The generic classification grouped patella fractures based on the fracture pattern into seven broad groups: nondisplaced, transverse with displacement, inferior pole, comminuted without displacement, comminuted with displacement, vertical and osteochondral.[31]

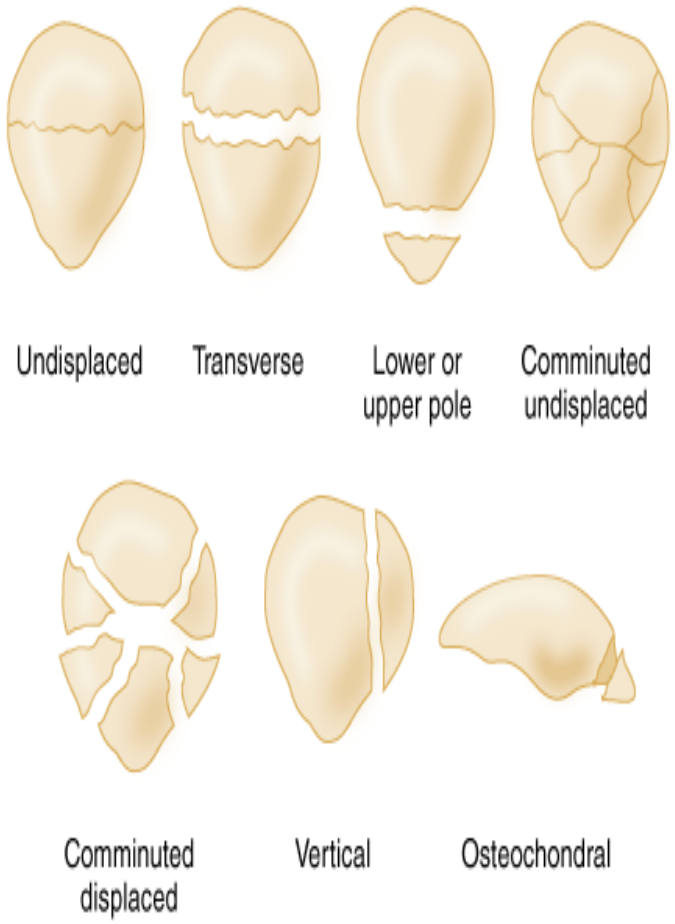

Figure 1: Patella fracture patterns [32]

This simplistic classification though quite useful in clinical practice, has no relevance in deciding treatment options and cannot help in prognosis.

The AO/OTA classification bridges this gap by providing a model that bears universal applicability in treatment decisions.[33]

Extra-articular (avulsion or isolated body) fractures: 34A.

Vertical partial articular fractures: 34B.

Complete articular fractures: 34C and graded in severity based on the amount of comminution as shown in figure 2.

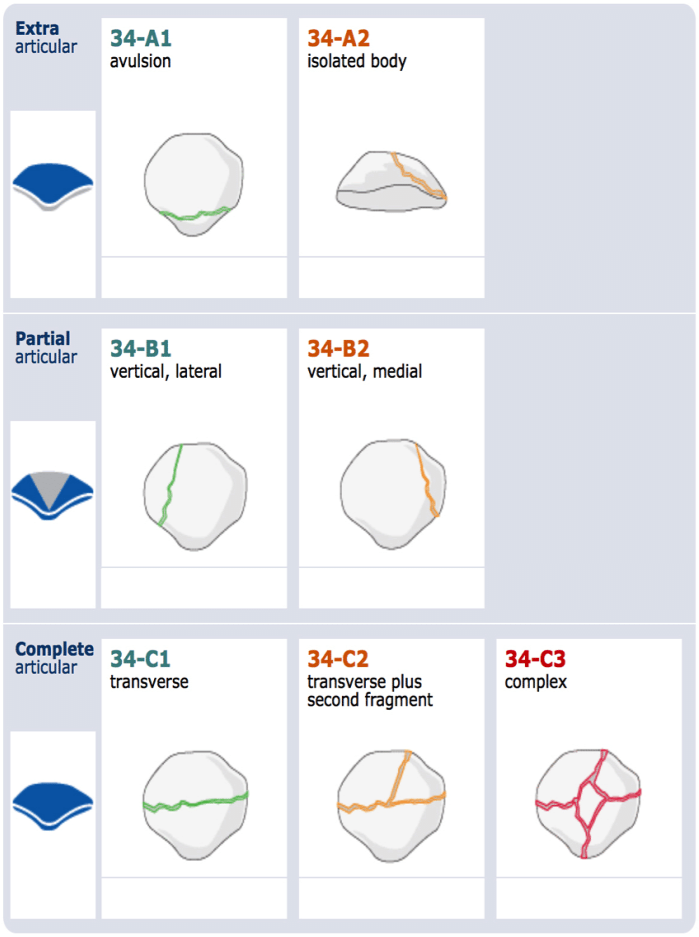

Figure 2: Classifications of patellar fractures according to the AO/ASIF, reprinted with permission of the AO Foundation[34]

Periprosthetic fractures have various classifications based on stability of the prosthesis, level of displacement, bone quality and timing of fractures. The classification by Ortiguera and Berry[24] is perhaps the most popular and helps in dictating treatment decisions.

Ortiguera and Berry Classification of Periprosthetic Patellar Fractures[24]

- Type I: Stable implant, intact extensor mechanism
- Type II: Disrupted extensor mechanism
- Type IIIa: Loose patellar component, reasonable bone stock
- Type IIIb: Loose patellar component, inadequate bone stock

Clinical evaluation

Patella fracture patients present with pain on the knee associated with swelling, and loss of extensor mechanism function. The injury mechanism dictates the possible fracture pattern. Transverse fractures are the most common fracture patterns, and they mostly result from dashboard injury on a flexed knee. Since the same mechanism can cause femoral neck fractures, hip dislocations and acetabular fractures, these injuries should be ruled out in patients presenting with patella fractures.

Simple falls and low impact injuries can also cause patella fractures in osteoporotic bones. Twisting mechanisms in sports injuries have been implicated in patella articular injuries and should be considered in patients presenting with patella dislocations and ligament injuries. In post-operative peri-prosthetic fractures, trauma may be quite subtle or completely absent.[35]

Clinical examination of the knee will reveal a tender, swollen knee with or without local evidence of injury, palpation of a gap in the patella and distorted extensor knee mechanism. Typically, these patients are unable to perform straight leg raise test. Because this may be limited by pain, the injection on local anesthetic agent before the test can improve its diagnostic yield. False negatives can exist in incomplete fractures and should be ruled out by radiography. Aspiration of blood in an injured knee is highly suggestive but not pathognomonic of patella fractures.

In most open fractures, the history of the penetrating object can be easily detected. In some cases where joint perforation is suspected but not clear from the history, the saline load test which involves the detection of air bubbles when 100-150mls of saline is injected into the knee, can be useful.[35]

Though clinical evaluation is quite helpful, Plain radiography of the patella in the anterio-posterior, lateral and axial views give away the diagnosis of patella fractures in most cases. The addition of the skyline view and an oblique view have been shown to increase the number of patella fractures detected by plain radiograph.[36]

In comminuted fractures, osteochondral fractures and occult fractures of the patella, computed tomography (CT) scan plays superior role compared to plain radiographs. CT scan has been reported to affect surgical management plans in 49% of patients and change fracture classification in 66% of patients.[37] Though magnetic resonance imaging can be quite useful in chondral fractures and in assessing the extensor mechanism, its use is limited in most patella fractures.

Treatment of Patella Fractures

Treatment options are predicated on the fracture patterns. The level of displacement, articular congruence, status of the extensors mechanism and available skill also play pivotal roles in making treatment decisions.

Conservative treatment with knee immobilization using cast immobilization, hinged knee brace or a knee immobilizer still remain a viable option for un-displaced fractures where the extensor mechanism is still intact. This treatment option is ideal for patella fractures with less than 3mm displacement and between 1-2mm articular displacement[1]. Displaced fractures in patients considered unfit for surgical treatment, patients with pre-injury knee ankylosis, those with extensor mechanism problems and the non-ambulatory patients can also have conservative treatment. Ambulation is usually allowed during conservative treatment and physical therapy is commenced as soon as immobilization is concluded. Conservative treatment has the drawback of knee stiffness and muscle weakness due to prolonged immobilization.

Surgical treatment options have evolved from the tradition use of stainless-steel k-wires transfixion of fractures with a

figure-of-8 cerclage configuration to the current use cannulated screw fixation, synthetic suture placements and mesh-plate fixation.[11] This evolution is primarily driven by the need to provide more stable and less irritative implants that will improve union outcomes, allow early mobilization of the knee and reduce the rate of re-operations.

Tension band wiring: The single most common operative treatment modality for the most common patella fracture pattern (displaced transverse fractures) still remains fixation with tension band wiring. This typically involved the use of two trans-osseous 2mm parallel stainless-steel k-wires placed perpendicular to the fracture line to maintain the fracture reduction and serve as anchors for placement of cerclage wires in a figure-of-eight pattern across the fracture. The tension band principle aims to convert the tensile forces generated at the convex anterior surface of the patella by the action of the quadriceps and patella tendons to compression forces on the articular surface needed to maintain fracture reduction and promote fracture healing. Meng et al[38] in their work on comparison of different methods of fixation of patella fractures found that tension band wiring was the most common method of fixation but admitted that some evolutions are emerging. The Arbeitsgemeinschaft fur Osteosynthesefragen (AO)/Association for the Study of Internal Fixation (ASIF) developed and propagated the tension band wire fixation technique as the standard of care for patellar fractures and have shown good results with the techinique[1]. It has been described by several reports as the gold standard for transverse patella fractures.[39,40,41,42] Posner and Zimmerman[43] in their review of patella fractures have noted that tension band wiring if properly done have shown consistently high union rates and progressively low re-operation rates

Though the Tension band wiring technique is quite suitable for transverse patella fracture, which give credence to its popularity, modifications to the classical technique have been reported.[14,39] Luo et al[14] have reported the use of additional encircling cerclage wires for more comminuted fractures to improve stability and called it the modified anterior tension band technique.

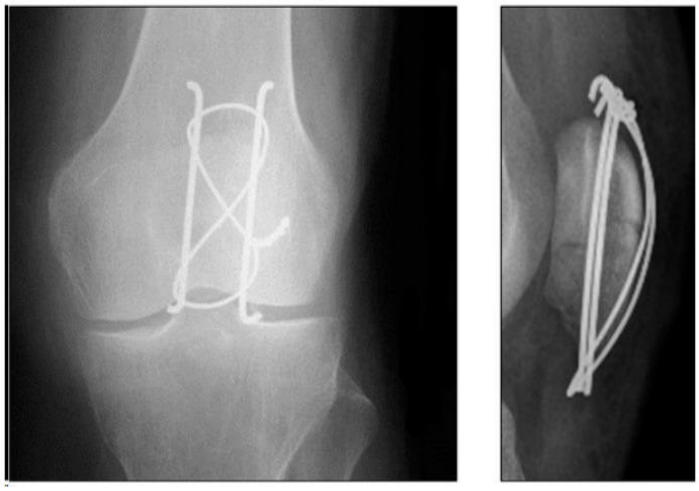

Figure 3: Tension band wiring. Copyright license-Swiss Medical Weekly supporting association[44]

This technique seems to have gained popularity in some centres in the tropical sub-region. The replacement of k-wires with cannulated screws and cerclage wire placed in a figure-of-8 configuration is another modification to the traditional method. This is believed to provide additional lag effect aimed at achieving better articular congruence and absolute stability. Wild et al[45] and other workers [46,47,48] have reported that this technique has demonstrated superior stability in biomechanical studies, lower complication rates, and better functional outcomes than Tension Band Wiring alone. The unique drawback of the tension band wire fixation technique is the subcutaneous placement of the implant and its effect on skin irritation and the frequent request for removal of implant as well as the occasional migration of the transfixion wires. These complications have been reported to be as high as 37% in some studies.[9,10]

Cannulated screw fixation: the replacement of transfixion pins with cannulated screw have been reported to increase the mechanical strength of the construct, improve resistance to implant back-out and reduce the risk of wire migration.[49,50] Reports have also shown higher union rates, with less need for implant removal with this method.[40,51] The replacement of initially used cerclage wire with high strength non-absorbable sutures around the cannulated screws in a figure-of-8 pattern or the use of cannulated screws alone have also contributed in reducing the earlier

problems of skin irritation. Reports have shown comparable union rates with traditional methods but with less complications.[52,53,54,55]
This fixation method may however be unsuitable for osteoporotic bone, fractures at the inferior poles and still have the potential for articular surface encroachment.

Plate fixation: Plate fixation is the ideal technique for stellate and inferior pole fractures. The plate options include the use fixed-angle locking plates and variable-angle mesh-plates. Mesh plates have the ability to be contoured for specific purposes. Patella plates have been to shown to have prevented fracture displacement under cyclical loading better than other fixation methods.[50,56,57] The subcutaneous placement of the plates and the issues of achieving tension-free wound closure are concerns about plate fixation.

Patellectomy: The partial or total removal of the patella is clearly a less-than-ideal treatment for patella fractures owing to the pivotal role of the patella in the knee's extensor mechanism. The Indications for partial or total patellectomy are drastically reducing in current orthopaedic practice with the emergence of several treatment options for the previously tagged 'irreconstructible' inferior pole patella fracture. These novel methods include the use of anchor sutures, mesh plates, mini-plates and non-absorbable suture fixations and have all shown excellent results.[59,60,61] Patellectomy (partial or total) is currently reserved for the severely comminuted fractures with fragmentation and poor bone quality[62,63] and cases of open fractures where bone fragments are either missing and no longer healthy enough to fix. Non-ambulant patients, those with previous failed attempts at fixation, tumours affecting the patella and cases of severely infected cases[49,63] may also be considered for partial or total patellectomy. Patella resections have been reported to cause 30-50% reduction in the quadriceps strength, distort the quadriceps function and lead to patella-femoral osteoarthritis.[49,62,63] Anand et al[7] have reported that the retention of at least 60% of the native patella, with advancement of the patella tendon, will have good clinical outcomes. The goal in these surgeries therefore should be to retain a reasonable size of the patella or maintain the continuation of the knee extensor fibers for optimally achievable extensor mechanism function.

Treatment of peri-prosthetic fractures
Peri-prosthetic fractures pose difficult problems and should best be reserved for the arthroplasty surgeon. A stable, functional extensor knee mechanism is vital to the success of total knee replacement surgery. Aim of treatment therefore is the achieve the functionally most obtainable knee extensor mechanism. The treatment options based on the classification be Ortiguera and Berry [24]is as stated in table 1

Physical therapy: Physical therapy is an essential aspect of treatment of patella fractures. Although no consensus exists, 4-6weeks of restricted movement with the knee placed in extension, followed by tolerated range of motion exercise is ideal for stable constructs. For constructs considered less stable, more prolonged immobilization is advisable. Ankle and hip stretches as well as isometric quadriceps strengthening exercises are also commenced early in treatment.

Conclusion
Patella fractures are inherently unstable owing to the distractive pulls at both ends of a fracture bone. Stable internal fixation that aims to convert these tensile forces to useful compressive forces have shown good clinical outcome. Other treatment methods are propelled by the need to provide less irritative implants with comparable union rates and less need for implant related problems. Patellectomy is less than ideal for the treatment of patella fractures and should be reserved exclusively for knee whose pre-injury condition is sub-optimal and when other treatment methods have failed. The future will perhaps provide better solutions to such knees. In view of the existing and emerging treatment methods, adequate counselling of patients is necessary to achieved desired results.

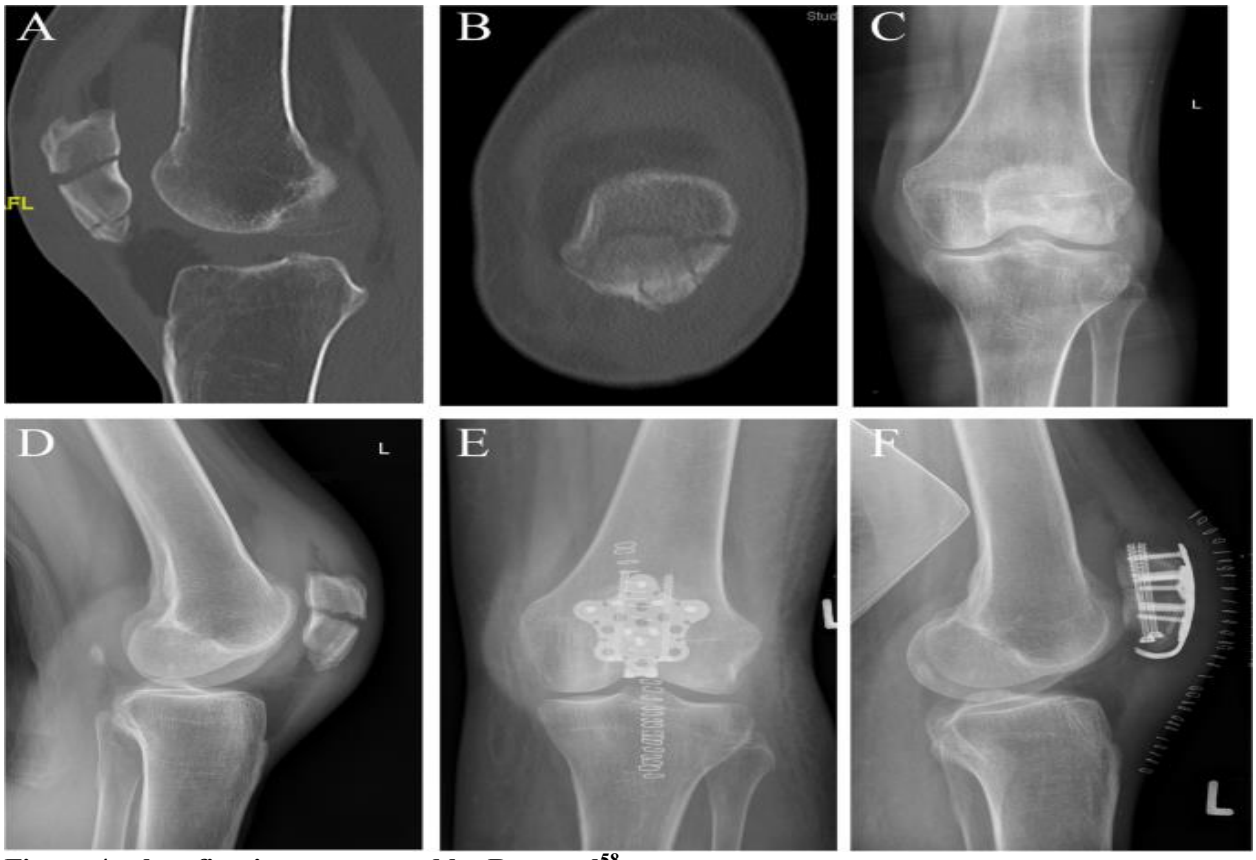

Figure 4: plate fixation as reported by Rau et al[58]

Table 1: Treatment options based on the classification be Ortiguera and Berry

SN	Types	Example	Treatment
1	Type I intact extensor mechanism	Un-displaced transverse fractures, vertical fractures, stable superior pole fractures	Conservative treatment
2	Type II Disrupted extensor mechanism	Transverse fractures with >2cm displacement. Stable component	Reconstruction of the extensor mechanism with suture and native/synthetic tendon grafts
3	Type IIIa: Loose patellar component, reasonable bone stock	Displaced fractures with patella component loosening.	Revision patellar arthroplasty or resection (patelloplasty).
4	Type IIIb: Loose patellar component, inadequate bone stock	Severely comminuted fractures with loose component and poor bone stock	Patelloplasty or total patellectomy

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