International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html

Management Options of Patellar Fractures

Sameh Mohamed Holyl, Ahmed Elsayed Eletawy Soudy, Hossam Mohamed Khiry, Hossam Fathi Mahmoud

Department of Orthopedic Surgery, Faculty of Medicine, Zagazig University, Egypt

Abstract

Patellar fracture is a common injury caused by excessive tension through the extensor mechanism or a direct blow. The intact patella increases the leverage and efficiency of the extensor mechanism and articulates with the femoral trochlea. Patellar fractures can lead to stiffness, extension weakness, and patellofemoral arthritis. In all types of patellar fractures, all attempts should be made to salvage the patella in order to preserve the biomechanics of the extensor mechanism of the knee. Non-operative treatment of fracture patella is indicated for non-displaced fractures of < 2mm fragment separation with intact extensor mechanism and articular step-off of less than 2mm. Operative treatment of patellar fractures is indicated in: Displaced fractures more than 2mm in its articular surface or 3mm of fragment separation, Comminuted fractures with disruption of the articular surface, Osteochondral fractures with displacement of loose body in the joint, Marginal or longitudinal fractures with commination or displacement.

Keywords: Patellar fractures.

Full length article **Corresponding Author*, e-mail: *drahmedsoudy10@gmail.com*

1. Introduction

The treatment of patellar fractures is based on [1]: The type of the fracture, the degree of displacement of the fractured fragments, the clinical presentation found on physical examination, and Age of the patient.

The overall goals of patellar fractures treatment are [1]: Preservation of patellar function. Restoration of continuity of the extensor mechanism. Reduction of complication associated with articular fractures.

There are several methods of treatment of patellar fractures including:

1. Non operative treatment.
2. Operative treatment which include:

a. Open reduction and internal fixation.
b. Percutanous fixation technique.
c. Arthroscopic assisted surgical technique.
d. Circular External fixator technique
e. Partial patellectomy.
f. Total patellectomy.

In all types of patellar fractures, all attempts should be made to salvage the patella in order to preserve the biomechanics of the extensor mechanism of the knee [1].

1.1. Non-operative Treatment

Non-operative treatment of fracture patella is indicated for non-displaced fractures of <2mm fragment separation with intact extensor mechanism and articular step-off of less than 2mm.

Treatment consists of:

a. Application of ice bags.
b. Elevation.
c. Application of a cylinder cast with the knee in extension.

In case of tense and painful effusion, aspiration of the injured knee joint is performed under strict aseptic technique [2]. The foot may be incorporated in the cast in the patients with conically shaped lower extremities to prevent inferior displacement of the cast. An alternative to the cast is the use of a hinged knee-range-of-motion brace. This brace should be locked in extension. Partial weight bearing with crutches is allowed during casting period with straight leg raising exercises. The cast should be maintained for 6 weeks with a regular follow-up radiographs to determine if the reduction has been maintained [1].

1.2. Operative Treatment

Operative treatment of patellar fractures is indicated in:

1. Displaced fractures more than 2mm in its articular surface or 3mm of fragment separation.
2. Comminuted fractures with disruption of articular surface.
3. Osteochondral fractures with displacement of loose body in the joint.
4. Marginal or longitudinal fractures with comminution or displacement [3].

- ***The goals of operative treatment are:***

1. Obtain an anatomic reduction.
2. Maintain the reduction with some form of stable fixation.

3. Restore the articular surface.
4. Repair the extensor mechanism.

All attempts should be done to salvage the patella or portion of it. Total or partial patellectomy is done only when the fracture is not reconstructable [3]. The patella is a subcutaneous bone with a minimal soft tissue covering, so as any other fracture, condition of soft tissue and overlying skin should be assessed preoperatively to determine the exact time to perform operation. Deep abrasions and extensive damage to the overlying skin may postpone the operation until the soft tissue has recovered. One or two weeks may be needed for partial thickness abrasion to heal which might make the fracture reduction and fixation more difficult.

1.3. Open reduction and internal fixation

There are several methods for fixation of the patella which include:

1. Wiring technique.
2. Tension band suturing technique.
3. Interfragmentary screws.
4. Cannulated screws with tension band wiring.
5. Staple technique.
6. Basket plate osteosynthesis.
7. Fixed angle plate osteosynthesis.

1. Wiring technique

There are several methods of fixation of patellar fractures using wiring technique which include [4]:

1. Cerclage wiring alone or with tension band wiring (Pyrford technique).
2. Tension band wiring alone.
3. Modified tension band wiring with two kirschner wires (AO method of fixation).

The principle behind tension band wiring of patellar fractures is to resist bending loads across the fracture as the knee is flexed. At this position there is a bending load across the patella caused by the angle between the quadriceps and the patellar tendon. If the tension on the anterior surface is carried out by the tension band, then there are compressive loads at the articular surface that improve fracture stability and presumably healing [5]. The Pyrford technique is a combination of Cerclage and tension band technique, the patella is held by circumferential Cerclage wire passed in a purse-string fashion close to the bone, a second stainless steel wire passed through quadriceps tendon, looping anteriorly across the patella and through patellar tendon to act as a tension band. This technique gives very strong strength and is useful for highly comminuted fractures which are difficult to be fixed by kirschner wires and simple tension band [6].

2. Tension-band suture technique

Although the use of stainless-steel wire for tension band fixation is common, more recently, braided polyester sutures have been utilized with success [7]. Many studies do claim that wire, particularly when it fails, is irritant to the patient, and often requires further surgery thus exposing the patient to the theoretical risk of further anesthesia. There is also an argument that knot irritation from a suture can be removed under a local anesthesia, whereas the removal of a wire requires surgery that is more extensive. Moreover, it is possible to bury the suture –knot within the soft tissue, whereas, the twists in steel wire are difficult to be buried in soft tissue, and often require tapping in via a punch [7]. A braided polyester suture was found to have minimal tissue reactivity when used clinically. Braided polyester suture is mechanically superior to other non-absorbable and absorbable sutures in vitro, combining properties of high stiffness and high ultimate tensile strength. In addition, braided polyester suture appears to maintain its mechanical characteristics in vivo [8]. Fixation with suture provides sufficient stability at the fracture site to withstand loads likely to be encountered during postoperative rehabilitation [7].

3. Interfragmentary screws

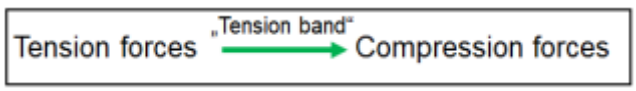
Modified tension band wiring is designed to resist the forces across the patella in flexion, but probably is not as effective in pure distraction when the knee is in full extension [9]. Some surgeons have used interfragmentary screws to prevent the fracture from sliding apart and to decrease the frequency of hardware irritation to the surrounding soft tissues. Biomechanically, the screws provide compression of the fracture site throughout the range of motion and resist tensile loading during the terminal extension range [9]. The patella is fixed using two parallel 4 millimeter cancellous screws. The proximal pole is over drilled so that the screws acted as lag screws if fully threaded screws are used, providing compression across the fracture site [5].

4. Cannulated screws with tension band wiring

Lag effect of partially threaded cannulated screws:The screw design being partially threaded allows for compression of the fragments, because drilling a thread hole allows the shorter thread length of the screw to incorporate the far fragment to slide on the shank toward the near fragment [10]. The function of the lag screw is to compress one piece of bone against another. This improves the stability of a reduction, so it is commonly used to achieve absolute stability, leading to direct bone healing, as opposed to healing with callus [11].

- ***Tension band effect***

A bending force applied eccentrically to a column (eg, bone, stick, etc.) causes tension and compression within that column [12]. To induce interfragmentary compression on a bending fracture a "tension band" is applied on the "tension side" of the bone. The “tension band” may be an implant (wire, plate). The principle makes use of the functional movement of the limb. Tension forces are converted into compression forces, provided the compression cortex is not deficient [13].



Tension band wiring is a fixation technique which results in absolute stability. Inter fragmentary compression and direct bone healing is obtained [12]. The use of screws alone, however, may not provide enough stability to resist the bending forces that occur with knee flexion. Because of this, others have recommended using a tension band in combination with interfragmentary screws. However, because the tension band wire cannot reliably engage the ends of the screws as they protrude from the bone, the wire may need to be drilled through the patella or just held in soft tissue. With the introduction of the cannulated screw for fracture

treatment, a new opportunity exists for combining screw fixation with tension band wiring of patella fractures. Wires can be inserted easily through the cannulated shaft of the screw and brought over the top of the patella, creating a secure tension band construct with the added advantage of interfragmentary compression from the screw fixation [5]. The fracture is first fixed with two parallel four-millimeter cannulated cancellous screws lagged across the fracture site.

An eighteen-gauge wire was then threaded through the cannulated screws to create a figure-of-eight pattern tension band across the anterior surface of the patella. Also, because the tension band is threaded through the cannulated screws rather than around K-wires, it can be laid down closer to the poles of the patella with less interposition of soft tissue, leaving less initial slack in the system than with the modified tension band technique. As the wires exit the ends of the screws, they can be subjected to sharp corners that might increase the risk of the wire breakage. This can be minimized by leaving the screws flush with or short of end of the patella **[5]**. The described fixation technique for transverse patella fractures had advantages including a low profile construct that caused lesser degrees of implant irritation to local soft tissue structures and was compatible with the use of early restricted motion. Whereas with traditional tension band wiring, the kirschner pins must protrude into the patellar and the quadriceps tendon and are often bent, which may cause local tissue irritation that inhibits motion and requires implant removal.

It also afforded a method to salvage cases in which traditional tension band wiring failed to maintain an anatomic reduction in osteoporotic bone [14]. Screw loosening and migration is prevented because the two screws are secured to each other. Furthermore, the anterior wiring prevents anterior fracture angulations during increased degrees of knee flexion when the patella is subjected to three point bending loads with a fulcrum that migrates proximally. This method is compatible with early motion, which may be helpful for the chondral component of this intra articular insult. Interfragmentary screw fixation provides more rigid and strong fixation than the modified tension band. Fractures stabilized with a modified tension band were found to displace significantly more than those fixed with screws alone or screws plus a tension band in simulated knee extensions. The fractures fixed with the cannulated screws plus the tension band failed at higher loads than those stabilized with screws alone or those with a modified tension band [5].

5. Staple technique

The biomechanical behaviour of a new staple technique for treatment of transverse patella fractures was investigated. Materials like Nickel–Titanium alloys (e.g. Nitinol) offer new perspectives for osteosynthesis techniques. Nitinol staples have already been used in foot surgery. Potential advantages of a staple fixation in contrast to the tension band wiring technique could be a smaller surgical approach and less osteosynthesis material resulting in less irritation of surrounding soft tissues. In addition, the surgical procedure may be simplified by a less demanding instrumentation. The biomechanical potential of this new method was investigated in vitro study.For each specimen two staples were placed orthogonally to the fracture line and symmetrically at 8–12 mm (depending on patella dimension) medial and lateral to the sagital plane of the patella. A surgical hammer was used to entirely drive the implants into the bone. Using staples for transverse patella fracture fixation is a novel approach which could reduce symptomatic hardware complications as compared to the tension band due to a smaller surgical approach and less hardware required. Although possibly advantageous from an instrumentation perspective, the main question of this investigation was if staples perform biomechanically similar as tension band wiring [15].

6. Basket plate osteosynthesis

Osteosynthesis of a patellar fracture allows anatomical repositioning of the fragments, reconstruction of the injured extension system and early rehabilitation of the leg [17]. Comminuted fractures of the patellar apex are conventionally treated by partial patellectomy with good results. The basket plate was designed for osteosynthesis of comminuted fractures of the patellar apex. This plate is basket shaped so that it will collect the fragments of the distal pole of the patellar together into the basket. There are four screw holes for malleolar screws or small spongious screw **[1]**. The basket plate is positioned into the patellar ligament, after fragment reposition, with its pedicles. After that, through the holes, screws are placed into the opposite fragment of the patella, providing dynamic compression at the site of the fracture. The system provides a stable osteosynthesis that allows loading of the operated leg without immobilization in the postoperative period with full body weight as soon as possible [17]. This method allows early postoperative rehabilitation without immobilisation. It meets the requirements of modern traumatology and has a special place in the surgical treatment of patellar fractures. The basket plate is primarily intended for the operative treatment of comminuted fractures of the patellar apex, but its obvious advantages in relation to the degree of osteosynthesis stability and possible early loading of the operated leg, suggest that its use might be extended to the other fractures of the patella [17].

7. Fixed angle plate osteosynthesis

The development of fixed-angle plates, which are based on the internal fixator concept, has led to an improvement in the biomechanical stability of the plate-bone interface.It has been possible to develop smaller and thinner fixed-angle plates with further enhanced biomechanical properties. A bilateral, polyaxial, fixed-angle 2.7 mm plate osteosynthesis system is specifically designed for use on the patella. The fixed-angle plate made it necessary to develop special 5- hole, 2.7 mm titanium plates, which allowed polyaxial, fixed-angle screw placement. Both the plates were bent in a semicircular shape prior to implementation. They were then placed on the medial and lateral surface of the patellae in an 80 degree angle to its anterior surface. The plates designed for patellar osteosynthesis also have an additional loop on both ends, which allowed the plates to be tensed with each other to attain additional stability in the traction direction of the quadriceps muscle. During the implementation of the plates, tapered surgical clamps were set in these additional proximal and distal loops used to tense the plates with each other and to stabilize the plates on the lateral and medial surface of the patella.

Figure (1): Cylindrical cast [1].

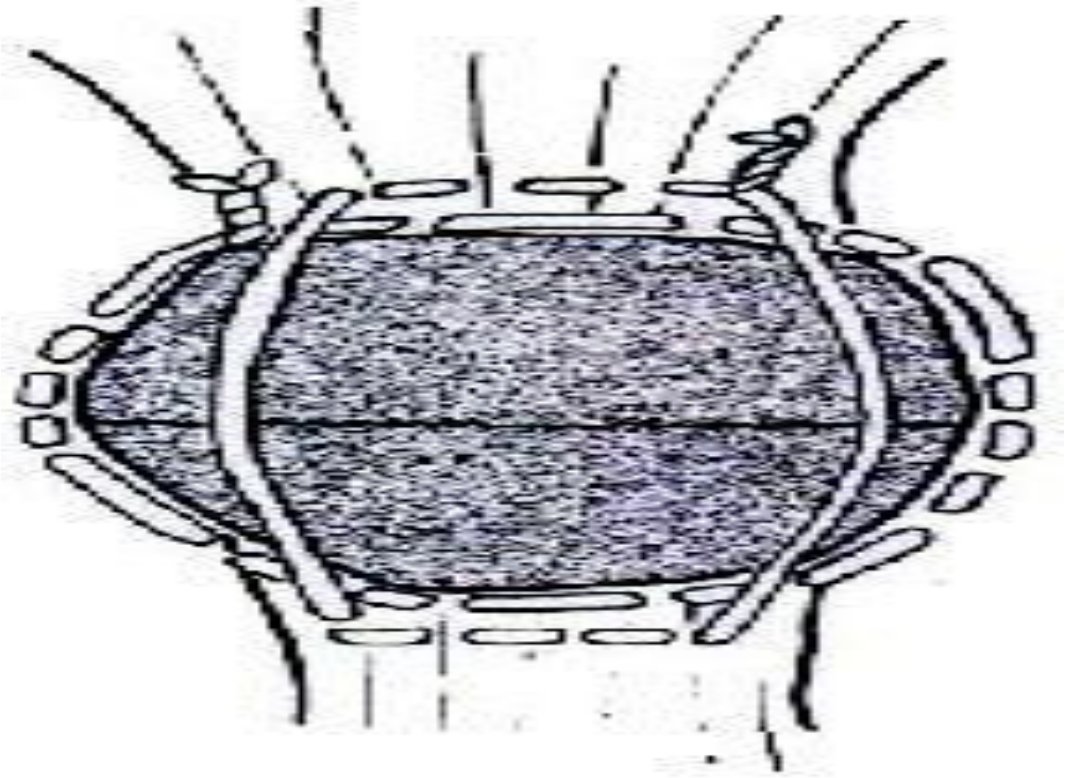


Figure (2): Pyrford technique [4].

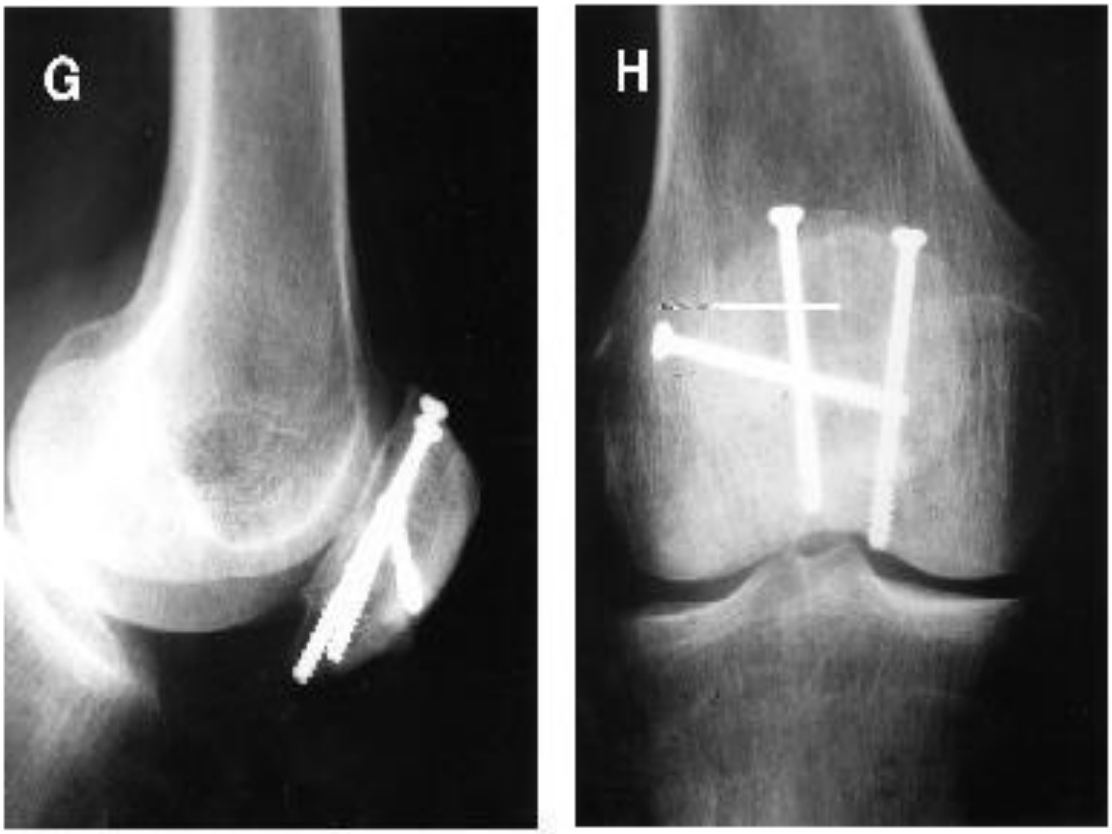
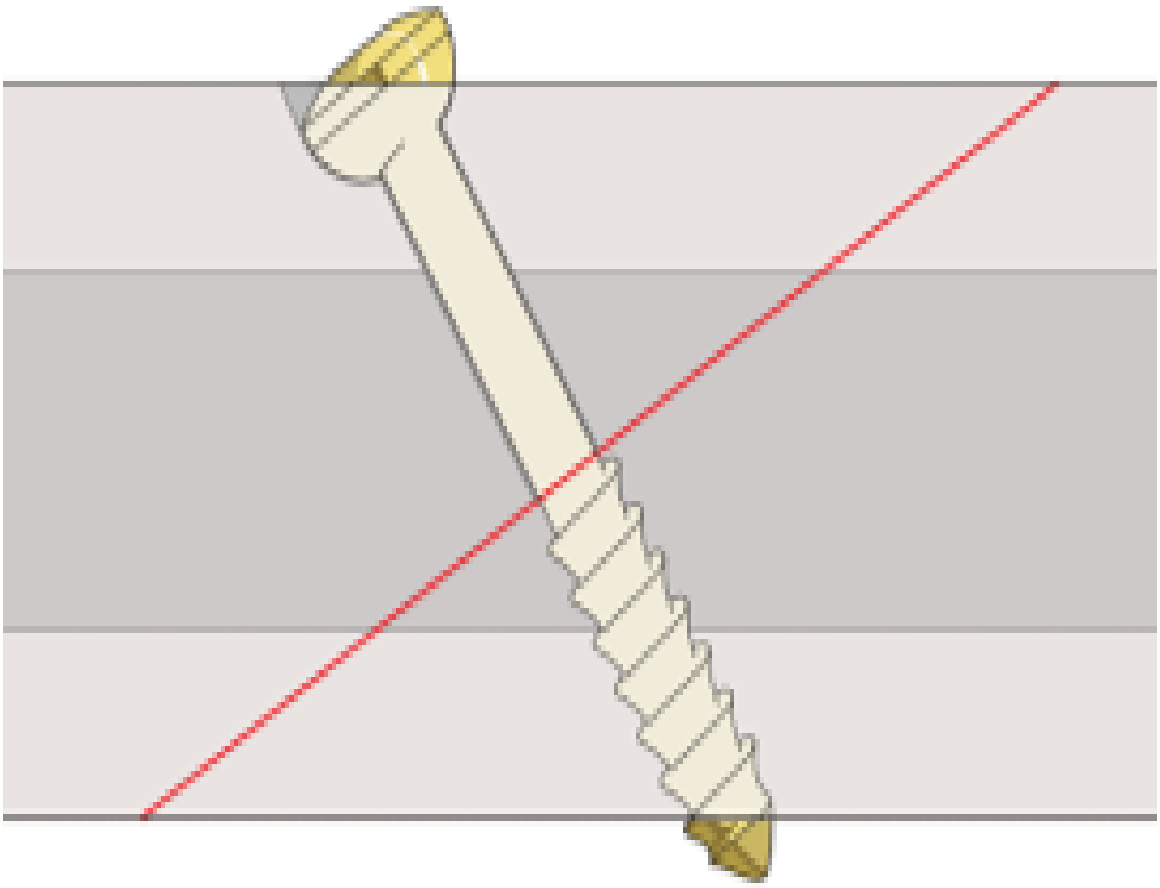


Figure (3): Fracture patella treated by Interfragmentary screws [5].

Figure (4): Cannulated partially threaded screws [2].



Figure(5): Lag effect of partially threaded screws [3].

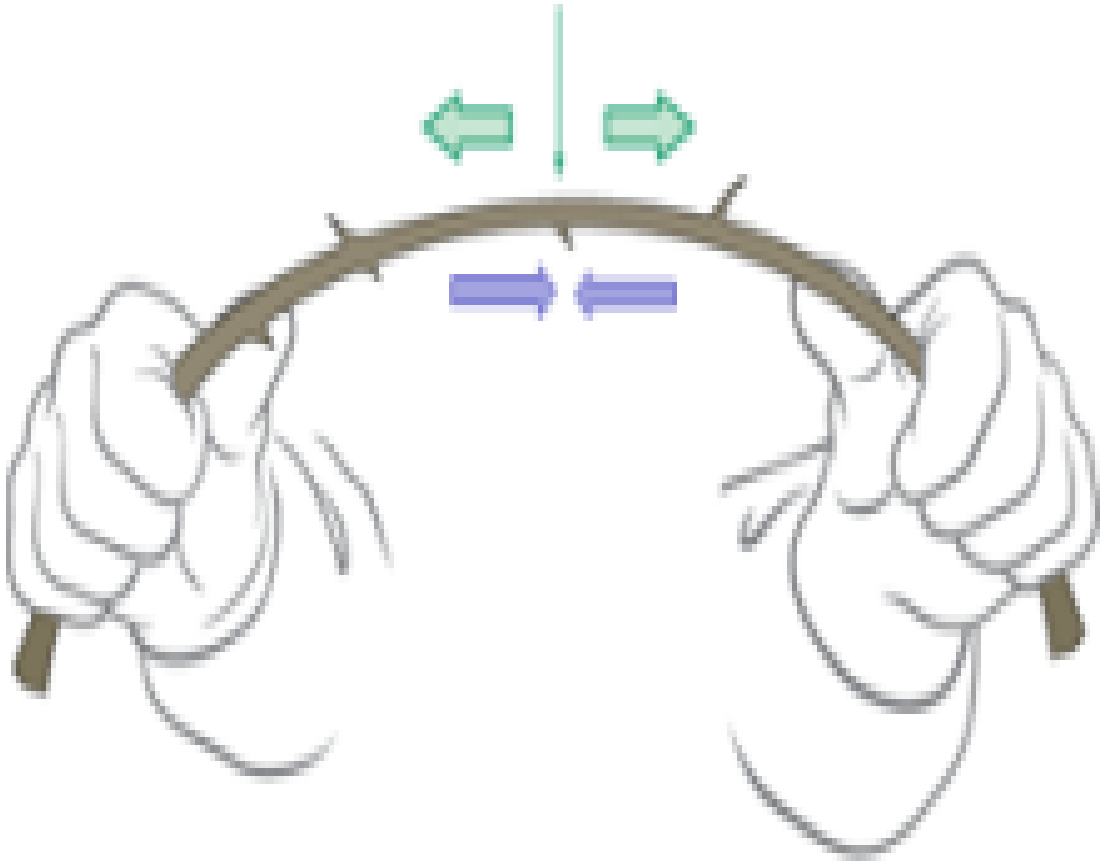


Figure (6): Tension and compression forces distribution when an eccentric bending force is applied to a column.

Figure (7): Fracture patella treated by cannulated screws with tension band wiring **[4]**.

Figure (8): Radiographs showing the instrumentations according to the staple technique [16].

Figure (9): Nitinol compression staples [15].

Figure (10): Lat and AP views of fracture lower pole patella fixed by basket plate [17].

Figure (11): Fixed-angle plate osteosynthesis of the patella [17].

Table (1): AO group recommend various forms of treatment of fracture patella as follow [18].

Patellar fracture (45)			**Therapy**	
45-A	**Extra-articular**	Pole fractures	Extensor mechanism disrupted	.Lag screw+ tension band wire or cerclage .Transosseous suture+cerclage
45-B	**Partial articular**	Vertical fractures	Non-displaced	Non operative
			Displaced simple	Transverse lag screw + cerclage
			Displaced multifragmentary	Circumferential cerclage +tension band
45-C	**Complete articular**	Transverse fractures	Disrupted extensor mechanism	K-wire +tension band wire
			Third fragment	Lag screw or K-wire +TBW
			Four or more fragments	K-wire, screws+TBW
			Comminuted fracture	Partial or total patellectomy

After securing the plates on the patella and drilling holes using a guide, a fixed-angle screw 3.5 mm in diameter was introduced into the proximal hole of the plate on each side. These screws spanned the fracture gap. The next step was to insert two similar screws into the distal holes on each side. Except for the center slot on the 5-hole plate, which lay right on top of the fracture gap, all the slots were filled with 3.0 mm diameter screws so that each plate was attached to the patella with four screws [17].

References

[1] D.P. Green. (2010). Rockwood and Green's fractures in adults. Lippincott Williams & Wilkins: pp.

[2] J.L. Henrichsen, S.K. Wilhem, M.P. Siljander, J.J. Kalma, M.S. Karadsheh. (2018). Treatment of patella fractures. Orthopedics. 41(6): e747-e755.

[3] E.C. Müller, K.-H. Frosch. (2021). Functional outcomes of revision osteosynthesis after failure of surgical treatment of patellar fractures. The Journal of Knee Surgery. 34(01): 080-086.

[4] S.T. Canale, J.H. Beaty. (2012). Campbell's operative orthopaedics e-book: expert consult premium edition-enhanced online features. Elsevier Health Sciences: pp.

[5] E. Müller, K.-H. Frosch. (2019). Fractures of the patella. Der Chirurg. 90: 243-254.

[6] D. Meng, P. Xu, D. Shen, Y. Chen, C. Zhu, C. Hou, H. Lin, Y. Ouyang. (2019). A clinical comparison study of three different methods for treatment of transverse patellar fractures. Journal of Orthopaedic Science. 24(1): 142-146.

[7] S.C. Hughes, P.M. Stott, A.J. Hearnden, L.G. Ripley. (2007). A new and effective tension-band braided polyester suture technique for transverse patellar fracture fixation. Injury. 38(2): 212-222.

[8] V.R. Patel, B.G. Parks, Y. Wang, F.R. Ebert, R.H. Jinnah. (2000). Fixation of patella fractures with braided polyester suture: a biomechanical study. Injury. 31(1): 1-6.

[9] C.-H. Chen, Y.-N. Chen, C.-T. Li, C.-W. Chang, C.-H. Chang, Y.-T. Peng. (2019). Roles of the screw types, proximity and anterior band wiring in the surgical fixation of transverse patellar fractures: a finite element investigation. BMC Musculoskeletal Disorders. 20: 1-10.

[10] Y. Tian, F. Zhou, H. Ji, Z. Zhang, Y. Guo. (2011). Cannulated screw and cable are superior to modified tension band in the treatment of transverse patella fractures. Clinical Orthopaedics and Related Research®. 469: 3429-3435.

[11] K.E. Banks, C.G. Ambrose, J.S. Wheeless, C.M. Tissue, M. Sen. (2013). An alternative patellar fracture fixation: a biomechanical study. Journal of orthopaedic trauma. 27(6): 345-351.

[12] A. Fortis, Z. Milis, V. Kostopoulos, S. Tsantzalis, P. Kormas, N. Tzinieris, T. Boudouris. (2002). Experimental investigation of the tension band in fractures of the patella. Injury. 33(6): 489-493.

[13] K.-L. Hsu, W.-L. Chang, C.-Y. Yang, M.-L. Yeh, C.-W. Chang. (2017). Factors affecting the outcomes of modified tension band wiring techniques in transverse patellar fractures. Injury. 48(12): 2800-2806.

[14] E.E. Berg. (1997). Open reduction internal fixation of displaced transverse patella fractures with figure-eight wiring through parallel cannulated compression screws. Journal of orthopaedic trauma. 11(8): 573-576.

[15] B. Schnabel, M. Scharf, K. Schwieger, M. Windolf, B. van der Pol, V. Braunstein, A. Appelt. (2009). Biomechanical comparison of a new staple technique with tension band wiring for transverse patella fractures. Clinical Biomechanics. 24(10): 855-859.

[16] F. Xiang, Y. Xiao, D. Li, W. Ma, Y. Chen, Y. Yang. (2023). Tension band high-strength suture combined with absorbable cannulated screws for treating transverse patellar fractures: finite element analysis and clinical study. Frontiers in Bioengineering and Biotechnology. 12: 1340482.

[17] A. Matejčić, B. Smiljanić, M. Bekavac-Bešlin, M. Ledinsky, Z. Puljiz. (2006). The basket plate in the osteosynthesis of comminuted fractures of distal pole of the patella. Injury. 37(6): 525-530.

[18] T. Ruedi, W. Murphy, C. Colton. (2000). AO Prinzihles of Fracture Management Thieme. Stuttgart. 864.