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Original Research Article

Outcome of Inferior Patellar Pole Avulsion Fractures: A Comparative Study

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ABSTRACT:

Introduction: The optimal treatment for inferior pole patella avulsion fractures has still been a topic of debate. The options include (a) internal fixation of the pole fragment and (b) resection of the avulsed fragment and repair of the patellar ligament to the patella. We present the comparative outcomes for patients with displaced inferior pole patella treated by resection and transosseous Ethibond® Krackow suture repair of patellar ligament with open reduction and internal fixation with modified tension band wiring and circumferential wiring. **Methods**: During a three year period between August 2013 and September 2016, twenty consecutive patients with distal pole fractures of the patella were prospectively enrolled in this study. These patients were divided into two groups. Group T patients were treated with open reduction and internal fixation with modified tension band wire and Group R patients by resection of the avulsed fragment and reattachment of the patellar ligament to the patella with #5 Ethibond®. Data entry and analysis was done by using SPSS version 20. Anatomical and functional outcome were compared. **Results**: Consecutive 20 patients were treated either with resection lower patellar pole (n=10) or with open reduction internal fixation with tension band wiring (n=10). Demographics were matched in two groups. Group T required a longer hospital stay (U=13.5, p=0.005). Complications were seen more often in Goup T compared to Group R (p=0.005). Group R had better scores (Bostman score U=6, p=0.001; SFMA U=7.5, p=0.001) and range of movement (p<0.05). **Conclusion**: Resection of the avulsed fragment and reattachment of the patellar ligament to the patella had better outcome according to the Bostman and SFMA dysfunction score, shorter hospital stay, and less complications as compared to open reduction and internal fixation with tension band wire and circumferential wiring.

Keywords: bone fractures • fracture fixation • patellar dislocation • patellar ligament • treatment outcome

INTRODUCTION:

Fractures and fracture dislocations of the distal pole of the patella are relatively rare, representing 0.5–1.5% of all fractures in general and account for 9.3% to 22.4% of all patellar fractures that are treated surgically.[1,2] An avulsion fracture of the distal patellar pole results from a blow to the flexed knee and the simultaneous forceful contraction of the quadriceps muscle.

The treatment of this type of fracture poses a special problem because of the extra articular location and comminution of the injured patellar pole. Various treatment options include tension band wiring (TBW), circumferential wiring, or use of screws.[3] The traditional method of treatment for displaced comminuted inferior pole fractures is excision of the comminuted pole followed by reattachment of the patellar tendon with trans osseous suture.[4,5] The reattachment of the ligament of patella to the proximal cancellous rough surface of fractured patella is controversial. Some trauma surgeons recommend attachment of the ligament of patella near the articular surfaces and others advocate reattachment near the anterior cortex.

Fractures of the distal pole of patella usually are less than 15 mm in vertical height.[6] There are

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few studies which mention the use of suture anchors for fractures of the inferior-pole of patella.[7] Some authors, however, have recommended preservation of the patellar pole by means of fixation with two cerclage wires.[8] Internal fixation with a basket plate is an alternative method of treatment that, in contrast with other methods, allows for the preservation of the patella.[9] Internal fixation with the basket plate is stable enough to allow for early mobilization and weight-bearing. However, such implants are not readily available and costly to the patient. This article represents our experiences comparing 20 cases of distal pole fractures treated by resection of comminuted avulsed fragment and transosseous suture repair with modified tension band wiring and circumferential wiring to see whether the technique achieve better knee function.

METHODS:

During a three year period from August 1, 2013 to September 30, 2016, sixty nine patients with displaced patella fractures were treated operatively in our hospital. There were 22 (15.3%) cases of displaced lower pole patella fractures (Fig 1A). The two cases in this study cohort were excluded due to lack of follow up. Patients with fractures that extended beyond the pole and those with sleeve avulsion were not included.

After institutional review committee approval, 20 patients were enrolled consecutively in this prospective study. All the patients gave informed consent prior to study inclusion. The decision was made by the treating surgeon whether type of surgical intervention (TBW vs resection) was required based on patient factors, fracture reduction and stability. The process was non randomized. Twenty patients were divided in two groups; Group T and Group R. Group T fractures were treated with open reduction and fixation with tension band wiring and circumferential wiring. Group R fractures were treated by resection of fragment and transossoeus repair of patella ligament.

Surgical techniques: Patients were placed in the supine position on a radiolucent table. One gram of cefazoline was given intravenously and a pneumatic tourniquet was used in all cases. Spinal, combined with epidural, anesthesia was used in the majority of cases. All surgery were carried out by consultant grade surgeon. We performed a standard midline longitudinal incision extending from the superior pole of patella to tibial tuberosity. Full thickness skin flaps were raised medially and laterally to expose the transversely ruptured retinaculum, fracture, and the patellar tendon. Fracture fragments were identified and irrigated with saline to remove hematoma. Comminuted inferior pole pieces were excised. In inferior pole fractures of patella, comminution is common and care is taken to preserve soft tissue attachment of patellar tendon to distal fragments (Fig 1B). Three vertical drill holes were made using a two mm drill bit directed through the posterior margin of fractured surface of proximal fragment and directed to the antero-superior border of patella (Fig 1C). A Krackow interlocking running suture with #5 Ethibond® was performed to each border of patellar tendon (Fig 1D). The free ends of sutures were passed through three transosseous tunnels in the proximal fragment through the opening of 16 gauge bone marrow aspiration needle with inside out technique and tied over upper border of patella (Fig 1E). The repair was further augmented by a 18 gauge stainless steel wire was passed through the patella superior pole and then passed through the hole made in tibia and was tighten sufficient to maintaining the height of patella (Fig 1F, 1G). Intra operative fluoroscopic images were taken to ensure that there was no tilting of the patella in the sagittal plane and knots were tied in the standard fashion. Care was taken to avoid any over tensioning of the knot which would have resulted in tilting of the patella in the sagittal plane. All the patients had varying degrees of retinacular tears which were repaired with zero size vicryl®. Knee flexion was checked at this time. The average flexion achieved on table was 80° (*SD*=4.2) and the repair was stable at this knee range. After insertion of suction drain, we performed a layered wound closure.

In the cohort of patients where open reduction and internal fixation with application of modified tension band wiring (TBW) was done, the standard surgical steps were followed. The procedure was also carried also out by a consultant grade surgeon. The procedure was conducted under intravenous antibiotics and tourniquet control using a similar midline incision. TBW and circumferential wiring was performed with two Kirschner wires (1.8 mm) and 18 G stainless steel wire (Fig 2A, B, C).

Operated knee were immobilized in full extension in a splint for about a month to allow for healing of retinaculum as well as healing of ligament to patella. Drain was removed on second postoperative day and X-rays were done at first postoperative day. Sutures were removed at two weeks.

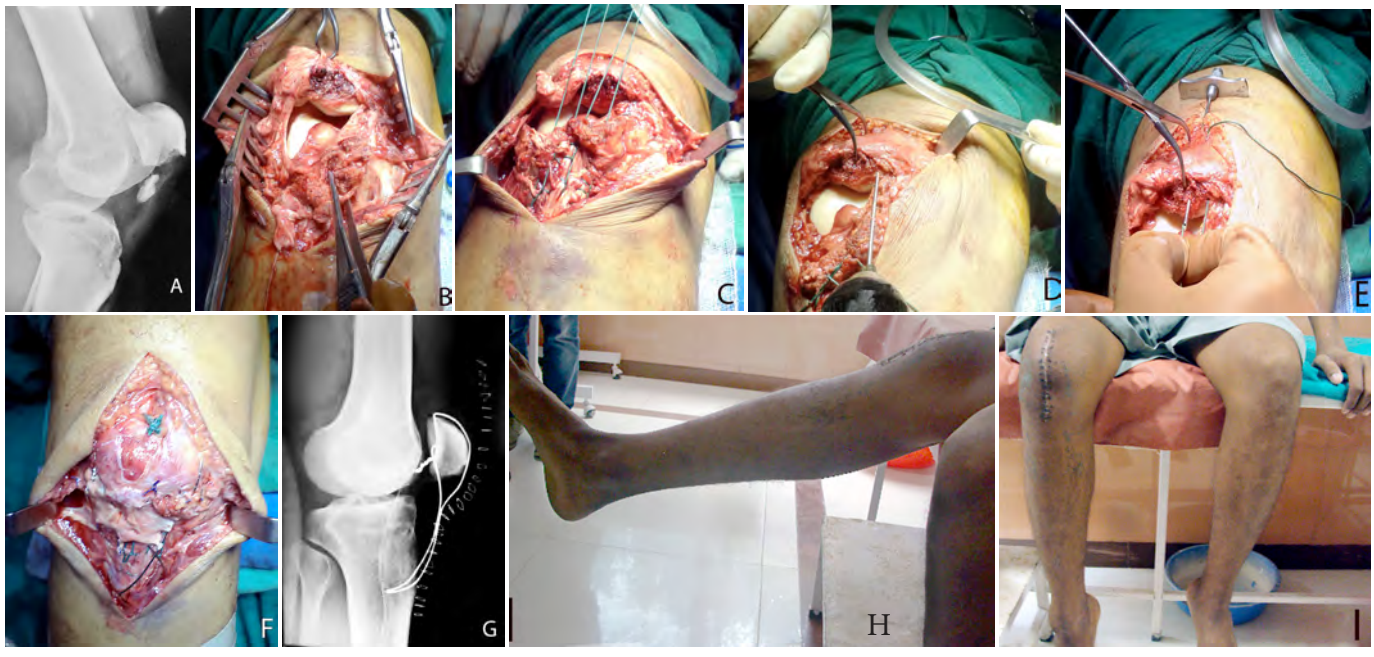

Fig 1 : (**A**) *Lateral radiograph of comminuted displaced lower pole fracture;* (**B**) *shows extra-articular location of the fracture ;* (**C**) *Drill holes were made using a 2 mm drill bit directed through the posterior margin of fractured surface of proximal fragment and directed to the antero-superior border of patella;* (**D**) *Interlocking running Krackow suture using #5 Ethibond1 each border of patellar tendon;* (**E**) *Free ends of suture passing through a bone marrow aspiration cannula;* (**F**) *Intraoperative photograph after the repair of retinucula. Fixation is augmented with patellotibial stainless steel wire cerclage.;* (**G**) *Postoperative lateral radiograph;* (**H,I**) *Function at 4 months follow-up.*

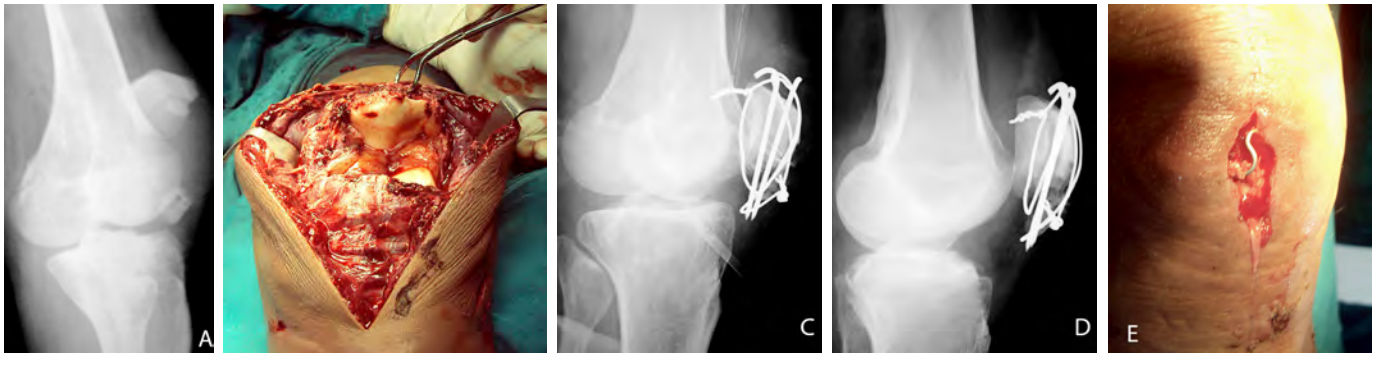

Fig 2: *A 45-year-old man fell from height and sustained a displaced patellar inferior pole fracture;* (**A**) *Oblique radiograph of the comminuted inferior avulsion fracture without articular extension;* (**B**) *Intraoperative photograph shows extra-articular location of the fracture with complete disruption of retinaculum;* (**C**) *Postoperative lateral radiograph shows fracture reduction and internal fixation with TBW and circumferential wiring;* (**D,E**) *Six months post surgery lateral radiographs shows fracture non union with infection and exposed end of wire.*

In the immediate postoperative period patients were encouraged to do isometric quadriceps exercises, straight leg exercises, and ankle pumps. No knee motion was allowed for the first four weeks. Patients were allowed weight bearing as tolerated with the help of crutches on knee immobilizer. The immobilizer was discontinued; range of motion and quadriceps and hamstring strengthening exercises were started at four weeks following surgery and crutches were gradually weaned off. All the rehabilitation was done under the direct supervision of a physiotherapist.

We recorded patient demography, injury mechanisms, fracture characteristics (open vs closed), time of surgery from injury (days), complications, range of motion (ROM), and flexion lag of operated knee compared to normal knee. At the final visit, all patients had radiographs and were asked to complete a validated outcome measure, the Short Musculoskeletal Functional Assessment (SMFA) survey and the Bostman scale.[10,11]

The data were collected in Microsoft Excel

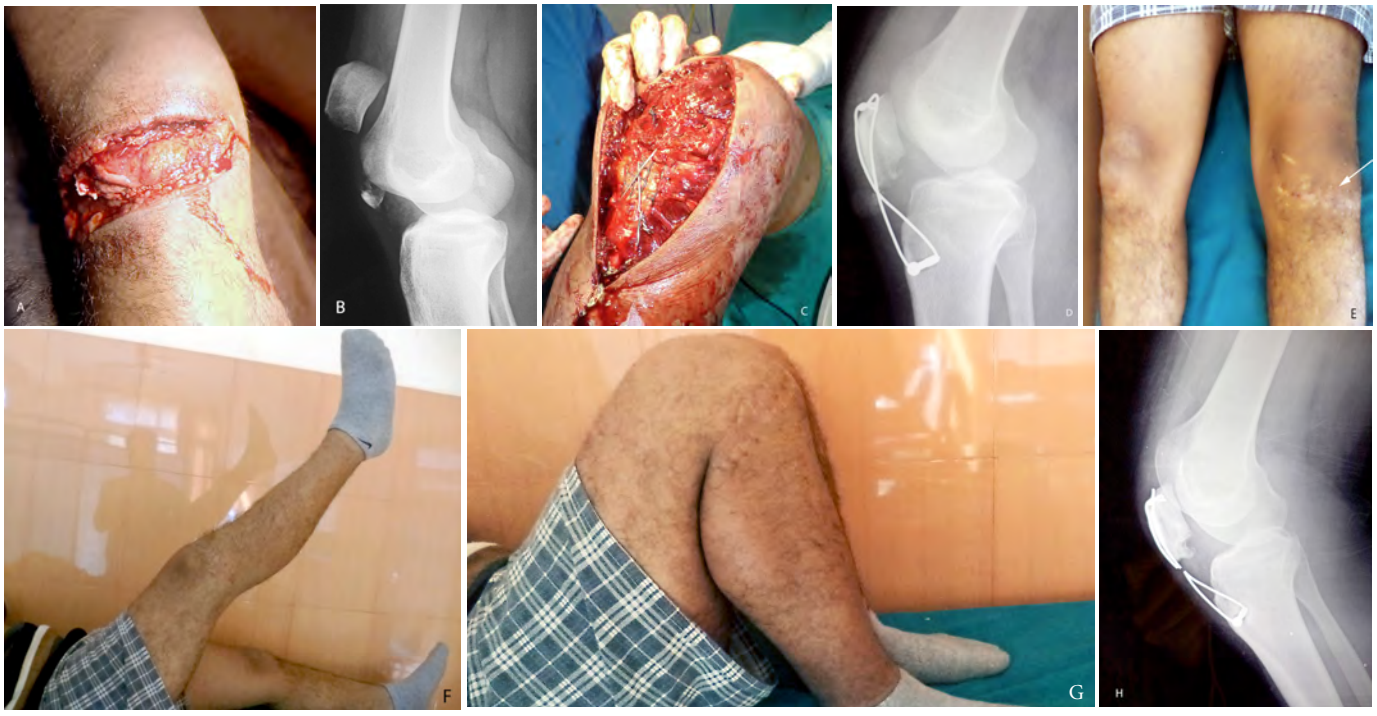

*Fig 3: (**A**) Compound patella fracture in 10 yrs old male following MVA; (**B**) Preoperative radiograph show displaced inferior pole patella fracture; (**C**) Intraoperative picture to ensure that there was no tilting of the patella in the sagittal plane following resection and transosseous repair of patella ligament with patellotibial fixation; (**D**) Postoperative lateral radiographs; (**E,F,G**) Ten months followup show excellent result without any loss of function; (**H**) A lateral radiograph taken 10 months postoperatively shows good healing (note broken wire).*

2016 (Office 16) and analyzed using the statistical package for the social sciences (SPSS) version 20 (SPSS Inc. Chicago, IL, USA). Descriptive analysis was performed to assess the baseline characteristics. For continuous data, medians with interquartile ranges (IQR) of Q_1-Q_3 in nonparametric data were calculated; the Wilcoxson rank sum test was used for analysis. Fisher exact test was used for comparing dichotomous variables between the two groups, and a p value <0.05 was considered significant.

RESULTS:

Demographic characteristics of both groups were comparable to each other, with preponderance of male patients (70%) in both groups; median (*IQR*) age of patient was 37.5 (28.5 - 40.5) in Group T and 30 (24 - 55.7) in Group R. There were no significant differences in gender (p=0.58 by Fisher exact test) and traumatized side (p=1) among both groups. In addition, mean time to surgery from injury in Group T (mean rank = 9.5) was not significantly different than that of Group R (mean rank 11.9; U=35.5, p=0.2). Regarding the mechanism of injury, in Group T, motor vehicle accidents in four (40%), fall in three (30%) and non-contact injuries in three (30%) whereas in Group R majority (n=8, 80%) were vehicle accident injuries. There were three compound (one Gustilo I and two Gustilo II) and one open (Gustilo IIIA, Fig 3A-I) fractures patella in Group T and Group R respectively. Two (20%) patients had an associated injury in each groups; posterior acetabular wall fracture and tibial spine fracture in Group R; posterior hip dislocation and subtrochanteric femur fracture in Group T. Duration of hospital stay was longer in TBW group (mean rank = 14.1) compared to Group R (mean rank = 7) and was statistically significant (U=13.5, p=0.006). Complications were seen more common in Group T (p=0.005, Fisher exact test). Four patients in the K-wire tension band group experienced skin irritation by wire ends after the operation; three patients had K-wire tension band loosening and proximal migration, and the fracture healed with the protection of a immobilization and the internal fixation was removed nine months later. Three patients experienced post operative wound infection and two of them required debridement, removal of wire, and secondary closure (Fig. 2E). In the resection group, no major complications were observed after the operations. Two patients had stitch knot irritation which resolved later. Two more patients experience weak knee on running only.

The range of motion, flexion lag compared to normal knee, Boston score, and the SFMA dysfuntion score were assessed at the end final evaluation,

the values of which are summarized in Tables 1. There was statistically significant difference found in both the scores with better scores in Group R. Furthermore, there was also statistically significant difference in the knee range of motion and flexion lag with Group R gaining better movement.

Table 1*: Outcome variables in both groups.*

Variables	Mean Rank		*Statistics*	
	Group T	Group R	*W*	*p*
Average Knee ROM	5.55	15.45	55.5	<.001
Flexion lag versus contralateral healthy knee	14	7.05	70.5	0.008
Bostman scale	6.1	14.9	61	0.001
SFMA	14.75	6.25	62.5	0.001

ROM - range of motion; SFMA - Short Musculoskeletal Functional Assessment dysfunction score; W - Wilcoxon rank sum value

DISCUSSION:

The inferior pole is an anterior cortical extension of the patella body devoid of articular cartilage. Many studies about resection of distal pole have proved clinically and biomechanically that there is shortening of lever arm of extensor mechanism.[7] Fixation of inferior pole with K-wire leads to reoperation rates between 20% to 50%. In many of these re-operated knees, restriction of knee joint range of motion developed. The modified anterior cerclage wire fixation is a standard treatment method for simple displaced patellar fractures.[12] The inherent weakness of the bone and the size of the fragments prevent rigid fixation by ordinary wiring or screws. Currently, the ideal treatment for avulsion fractures of the inferior pole of the patella has not yet been distinguished. The options include: internal fixation of the pole fragment, resection of the avulsed fragment, and repair of the patellar tendon to the patella.[13]

In the present study, the final outcome was assessed by using Bostman scale and SFMA score. Patients in Group R, who were treated with re-attachment, had better outcome as compared to Group T patients who were treated with tension band wiring. The functional outcome in different studies shows that fixation with K-wires and basket plate is definitely inferior to excision of patella.[14] These results were consistent with the results reported by study of Anand et al.[4] The comminuted fracture of inferior pole of patella was investigated by Chang et al. and reported that fixation usually fails and different metal implants does not offer any protection against failure.[13]

Excision of the fragments of bone with attachment of the patellar tendon by transosseous pull-out suture is usually indicated when the fragments are severely comminuted.[15] The weakness of synthetic non-absorbable sutures and distal partial patellectomy require splint immobilization of the knee after operation, which delays rehabilitation and may result in quadriceps muscle atrophy and weakness. In 14 patients treated with pole resection and tendon reattachment by Kastelec and Veselko, the involved knee was immobilized in a cast for five to seven weeks (average, 6.5 weeks) postoperatively.[16] In the current study all knees were immobilized for a month. Although mobilization was delayed in our cases there was no such compromise on the final outcome.

Some authors advocate reinforcement by patellotibial tubercle cerclage or the use of figure-of-eight wiring to protect the suture to allow early rehabilitation, but these procedures make it difficult to adjust the length of the patellar tendon. This may result in multiple breakage of the wire and require a secondary revision. Furthermore, a low lying patella disrupts the normal physiology of the patellofemoral joint and may cause long-term problems.[15,17,18] Five of our patients required an additional patellotibial cerclage to protect the repair. However, none of them developed anterior knee pain.

Recently, improved suture material and bone anchor techniques have provided sufficient strength for early mobilization after patellar tendon repair, as shown both in biomechanical studies and clinical applications.[19,20] However, bone anchors are not recommended for inferior pole avulsion fractures, because the purchase of a bone anchor depends on having an intact cortex.[20]

Saltzman et al. evaluated the results of pole resection, but that study did not include only avulsion fractures but rather included all fractures for which partial patellectomy had been performed.[15] Pelzl evaluated the results for sixty-four patients with comminuted fractures. Twenty-eight of the fractures had been treated with partial patellectomy, which was performed in all cases in which a solid proximal fragment formed at least two-thirds of the patellar size.[22] However, neither those nor other similar studies evaluated avulsion fractures of the patellar pole separately.[15,21]

Distal pole fractures were treated by suture fixation by Schuett in 2015 in 13 patients and at one year follow up 20% of the patients were having

poor or unsatisfactory results.[22] To improve the knee function in these difficult fractures, arthroscopic excision of distal pole fractures and re-attachment of the patellar ligament to the proximal patellar fragment has been advocated and investigated. Short-term results are encouraging and this might prove to be the treatment of choice in the near future.[23]

We had a small size of study group as these fractures are rare, accounting for only 9.3% to 22.4% of all patellar fractures.[2] We identified twenty two cases of inferior pole avulsion fracture among sixty nine patients patellar fracture in our institution. Limitations of this study were less number of cases, absence of controls, and short follow up period. We did not consider radiographic indices evaluation such as patella height. More laboratory studies and randomized control trials are required to validate our point.

CONCLUSION:

The study demonstrated that excision of the distal pole and trans osseous repair with Krackow suture using Ethibond® for inferior pole fractures of the patellar ligament is a better option in comminuted inferior pole patella fractures. The functional outcome is good to excellent and complication is low with this treatment mode. To further enhance this treatment method long term follow ups are required.

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Conflict of Interest: None declared

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