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Dr. Vasav Somani
Seth G.S. Medical College and K.E.M. Hospital, Mumbai, Maharashtra, India

Dr. Sujata Aiyer
Seth G.S. Medical College and K.E.M. Hospital, Mumbai, Maharashtra, India

Dr. Surendar Singh Bava
Seth G.S. Medical College and K.E.M. Hospital, Mumbai, Maharashtra, India

Dr. Rajendra Phunde
Seth G.S. Medical College and K.E.M. Hospital, Mumbai, Maharashtra, India

Corresponding Author:
Dr. Vasav Somani
Seth G.S. Medical College and K.E.M. Hospital, Mumbai, Maharashtra, India

A case series of traumatic extensor mechanism rupture managed by extensor mechanism reconstruction using Z-plasty of Quadriceps tendon and autologus tendon graft augmentation

Dr. Vasav Somani, Dr. Sujata Aiyer, Dr. Surendar Singh Bava and Dr. Rajendra Phunde

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Abstract
Extensor Mechanism Injuries of knee are rare. True incidence of traumatic Patellar tendon rupture is unknown but is third in sequence after neglected Patellar fracture and quadriceps tears. Often the diagnosis or treatment of such cases are delayed, hence the biggest challenge here is to the need to bridge the gap caused by the contracted quadriceps muscle or the patellar tendon. i.e. Patella baja in quadriceps rupture and Patella alta in patellar tendon rupture. The goal of treatment is to bring down the displaced fragment and maintain its position by lengthening the contracted tissue and restore the Extensor mechanism through a bone to bone or a tendon to bone repair.
We have treated 2 cases of delayed presentation of Extensor mechanism Injuries. The first case was a 40-Y-M with patella non union and the second case a 35-Y-M was a Left tibial plateau fracture (type -2) with ruptured Patellar tendon and associated ligamentous injuries. Both the patient were managed by reconstructing the Extensor mechanism.

Keywords: Extensor, patella, reconstruction, autograft, quadriceps

Introduction
Injuries to extensor mechanism are often seen in individual over 40 years of age, often associated with underlying medical conditions such as gout and Diabetes Mellitus. Often it is difficult to bridge the gap between two ends, for such problems one may perform tendon lengthening procedures or Allograft or Autograft augmentation. In a study Published by Conner J. Paez, one such repair has been described for chronic quadriceps tendon injury suture anchor repair with V-Y Plasty and Achilles Allograft augmentation [1].

Materials and Methods
2 patients, both male with an average age of 37 (range: 35-40), with a past history of trauma were prospectively followed up for a period of 13 months after operative intervention carried out in 2020. Both the patients achieved active extension, good range of motion at the knee joint with no associated complaints at knee joint.

Case Report
A 40-Y-Old male, Security guard by profession, presented to us with a 9 week old history of trauma due to fall on knee with the chief complaints of anterior knee pain, inability to sit crossed leg with difficulty in extending the knee. The patient was able to walk without support. On Examination, the patient on inspection had quadriceps wasting on comparing to normal side. On palpation, the patient had a palpable patellar gap which was 7cm on flexion and decreased to 3 cm on extension. The superior pole of patella was found proximally migrated by 7cm in distal thigh. He had a extensor lag of 50 degrees which was passively correctable till 5 degrees of flexion. His range of flexion was normal (0-140 degree). The patient had bilaterally palpable pulse with intact nerve function.

Fig 1: A, B): Pre-operative plain antero-posterior and lateral radiographs suggestive of displaced patellar fractures with superior migration of proximal pole (C, D): Left knee extensor lag of 45 degree which is passively correctable to 5 degrees of extension, (E,F): Palpable patellar gap between two fragments, A gap of 7cm between two fragments seen on knee flexion)

Following the examination findings and radiological Images, an MRI was done to rule out Intra-articular pathologies.

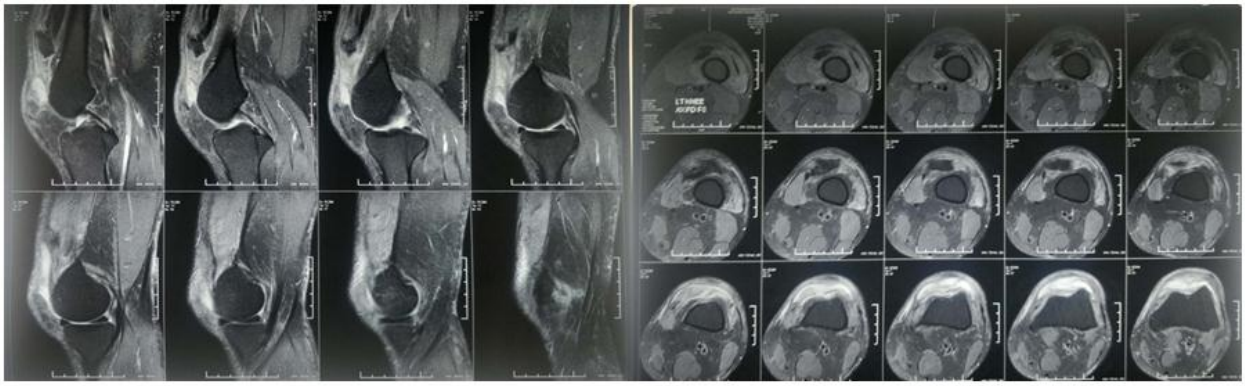


Fig 2: Preoperative MRI: Saggital view and axial view showing Post-traumatic superior patellar pole avulsion with tear in anterior fibres of quadriceps tendon.

Our plan was to lengthen the quadriceps mechanism with a Z-plasty and bridge the gap using a Peroneus longus autograft.

Surgical Procedure

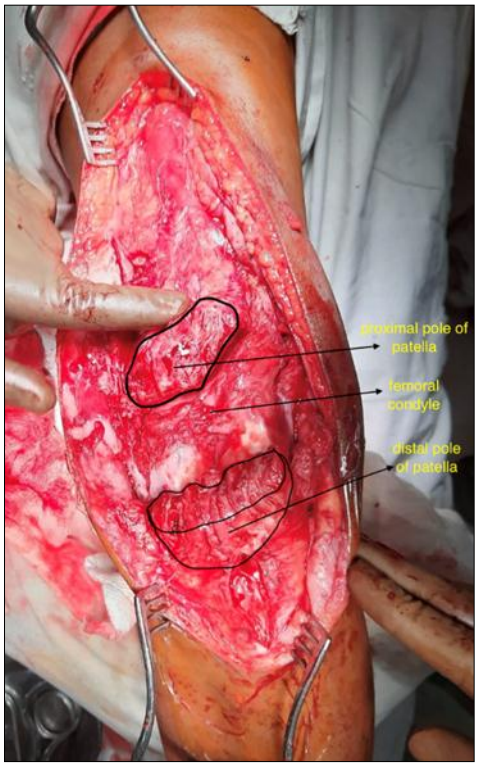
Plan

1. Partial excision of proximal fragment
2. Z plasty of quadriceps tendon
3. Augmentation with ipsilateral Peroneus longus tendon

Anesthesia: Spinal with epidural catheter
Position: Supine with a bolster under the ipsilateral hip.
Examination under anaesthesia: The proximal and distal poles of the patella were marked adjacent to the non union.

Incision: a midline incision was marked over left knee from the tibial tuberosity to 10cm proximal to proximal pole of patella.
Infiltration of 50cc saline adrenaline (1:20 dilution) was done along the incision.
On incising the skin over the area of the gap non-union, there was egress of synovial fluid through the incision.
Proximal and distally, normal tissue was exposed. The rectus femoris muscle and patellar tendon respectively were identified. Dissection then proceeded to the site of injury.
There was a layer of fibrous tissue covering the proximal pole of patella and the quadriceps mechanism which was incised and separated from the underlying vastus medialis and lateralis.

The lateral and medial gutters were exposed. The distal pole of patella was completely exposed and retracted anteriorly to expose and examine the femoral condyle and knee joint which were un-injured.

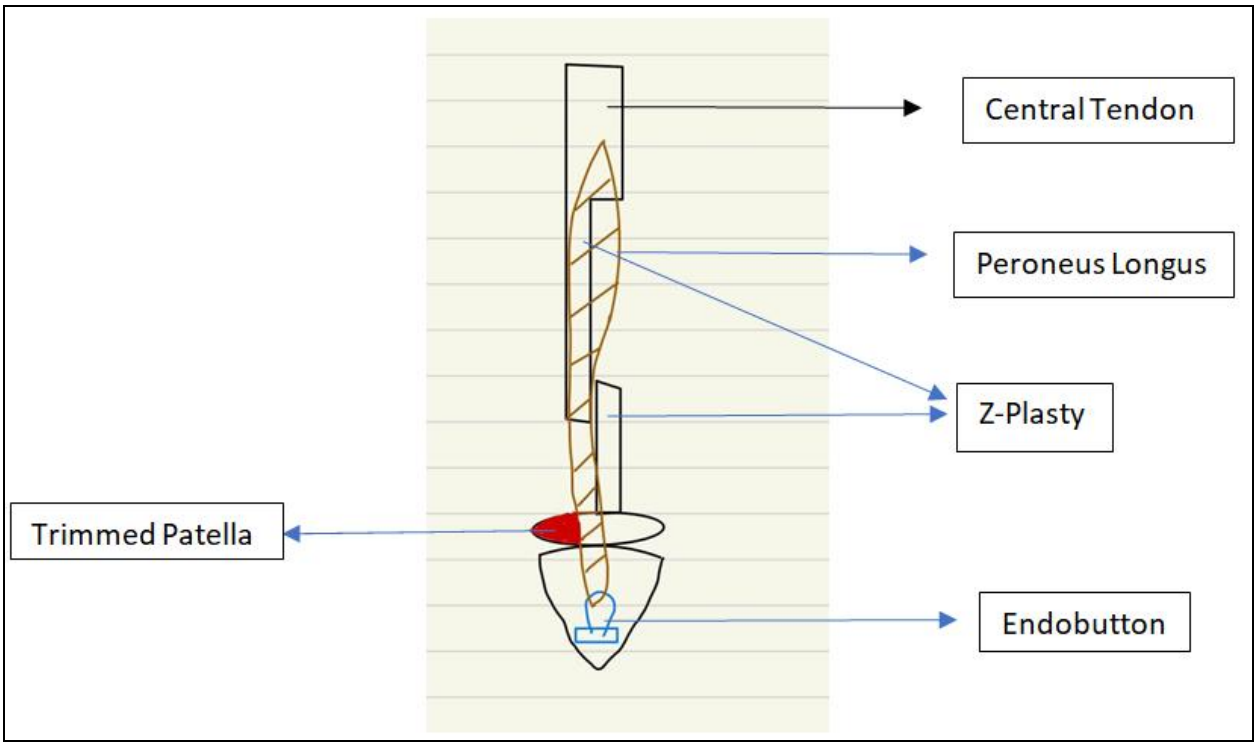


There was a gap of 3cm between the poles of the patella with the knee in full extension. This increased to 7cm with the knee in 120 degrees of flexion.

A lateral release was done by cutting the fibrous tissue lateral to the proximal pole. The vastus lateralis was dissected off the central tendon, comprising the rectus femoris and the vastus intermedius, for a length of 7 cm. The undersurface of the quadriceps tendon was exposed by releasing loose connective and fibrous tissue connecting it to the thick periosteum and synovial tissue covering the distal femur. The vastus medialis muscle was similarly released from the central tendon.

The central tendon was lengthened by 9 cm in the saggital plane using a Z-plasty, this being 2 centimeters longer than the length of the gap in 120 degrees of flexion. The lateral half of the central tendon was cut distally and the medial half cut proximally. The lateral half of the proximal patella was excised to allow smooth passage of the peroneus longus graft.

The proximal pole of the patella with one half of the lengthened tendon, was brought distally to approximate with the distal pole of the patella. The ends of the z-plasty were sutured side to side over a span of 2 cms.



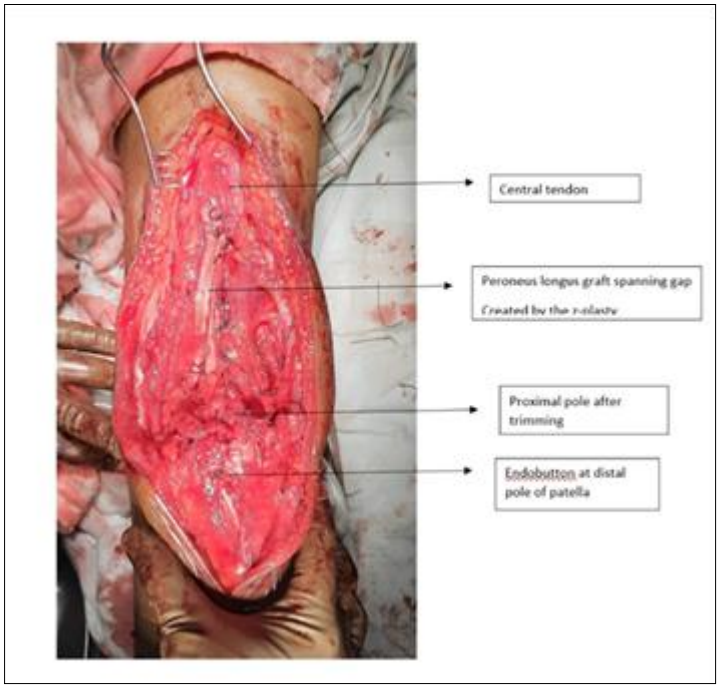
The medial and lateral defects created as a result of the z-plasty were augmented with ipsilateral peroneus longus autograft as follows:

1. Harvest of peroneus longus tendon: Using lateral malleolus as reference, a longitudinal incision 3 cm above and 1 cm behind was taken. After incising the superficial fascia, the Peronei group of tendons in the lateral compartment of leg were identified. Whip stitches were taken in the distal part of Peroneus longus and it was split around 3 cm above the lateral malleolus. Side to side whip-stitch were taken to suture distal part of peroneus longus and peroneus brevis. The tendon of peroneus longus was stripped in proximal direction using a tendon stripper at about 5 cm distance from the fibular head in order to avoid injury to Peroneal nerve. Graft preparation was done using a standard procedure of suitable size.

Passage of endobutton with loop through the distal patella

A beath pin was passed in an antegrade manner through the distal patella fragment positioned centrally in anteroposterior and lateral views. It was overdrilled using the endobutton reamer. An endobutton with 15mm loop through which a doubled peroneus longus graft had been passed, was flipped over the distal pole.

The peroneus graft was then sutured side to side to the distal portion of the Z-plasty, and into the proximal stump using pulvertaft and side to side stitches with 1(0) vicryl.



The knee was kept in 90 degrees of flexion while suturing the z-plasty and during the augmentation.

The released vastus lateralis and medialis were sutured back to the central tendon using 1/0 vicryl.

The wound was closed in layers. No drain was used. An above knee cast in 0^0 extension was applied.

Post operative protocol

Active ankle movements and static quadriceps exercises were encouraged. Weight bearing mobilization using axillary crutches was allowed. The cast was removed at 3 weeks for suture removal. A cylinder cast was applied and removed 6 weeks later. (total 9 weeks of immobilization). At 13 months follow up currently the patient is ambulatory without support, no ankle pain, with no difficulty and climbing stairs with no associated difficulty in sitting crossed leg.

Current ROM

1. Flexion: 0-90 degrees.
2. Extension: No Extension lag

Fig 3: Left to right Flexion range of 90 degrees, Complete extension at 6 monthly follow up.

Case 2

A 35-Y-Male presented to our clinic with a 10 week old history of RTA with right comminuted distal tibia-fibula diaphyseal fracture with left tibial plateau fracture(type -2) with left distal 1/3rd diaphyseal fracture of tibia with ruptured patellar tendon from tibial tuberosity, fracture of gerdy's tubercle, segond fracture, ACL tear, tear of lateral meniscus from capsular junction, Partial tear of MCL, disruption of proximal tibio-fibular joint with a chief complaints of pain in bilateral knee and ankle, inability to walk and deformity in right lower limb with Nil distal neurovascular deficit. The patient had suffered a head injury following trauma and subsequently he tested positive for Covid-19 following which no orthopaedic intervention couldn't be carried out for 10 weeks.

On Examination

	Right Limb	**Left Limb**
Swelling	Absent	Absent
Tenderness	Present	Present
Knee ROM	0-90 degree	0-80 degree
Ankle ROM	Painful & Restricted	Painful & Restricted
	Anterior Drawer test Positive Varus/Valgus Stress test positive	

Fig 4: Left to Right [A,B]: Anterior Drawer test, [C,D]: Varus-Valgus Stress test

Fig 5: (A) Top row from left to right, Preoperative and Postoperative Radiographic Images of Right leg. (B) Middle row Left to Right Preoperative and Postoperative Radiographic images of Left Knee. (C) Last row Radiographic Images of Left Leg

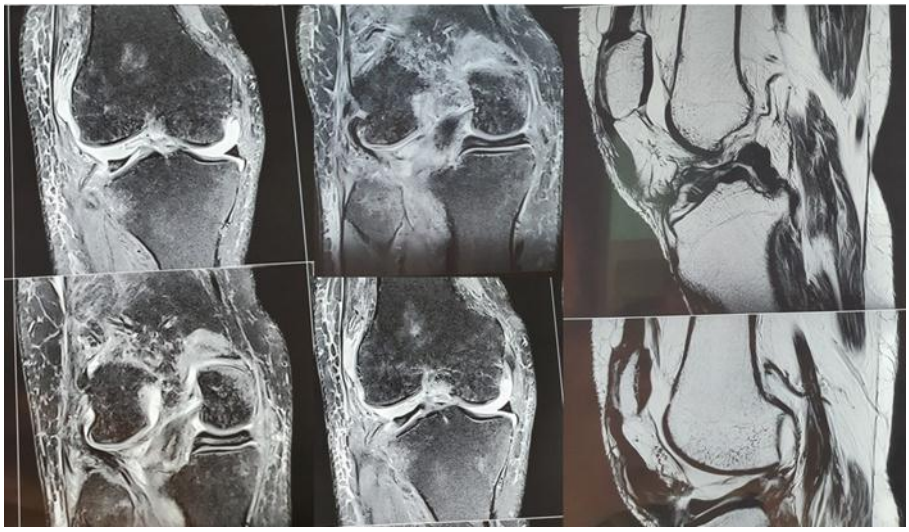


Fig 6: Left side: T2W coronal cuts of MRI suggestive of Anterior cruciate ligament tear, Medial collateral ligament tear, tear of lateral meniscus from menisco-capsular Junction, gerdy's tubercle fracture, segond fracture, depressed fracture of lateral condyle. Right Side: T1W saggital cuts suggestive of Patellar tendon rupture from tibial tuberosity.

The patient was managed with open reduction Internal fixation for right side fibular plating and Interlock nailing for tibia. The left side distal tibia diaphyseal fracture was managed conservatively due to poor skin condition and the left knee was planned to manage as follows:

Surgical Procedure

Our Plan was to do a staged reconstruction of Left knee

1st Stage

1. Patellar tendon reconstruction
2. Suturing of lateral meniscus
3. Elevation and bone grafting of Lateral tibial condyle
4. Fixation of gerdy's tubercle

2nd Stage (After 2 Months, If Required)

1. ACL reconstruction
2. MCL Reconstruction if still lax
3. Posterolateral corner reconstruction

Position: semi-lateral provides easy access to both anterior and posterolateral knee.

Skin incisions: Long midline incision for access to knee joint. Short incision behind the fibula to explore the peroneal nerve.

Plane between the deep fascia and muscles developed. Knee joint open lateral to the patella due the avulsion of the gerdys' tubercle and anterolateral joint capsule.

Intraoperative findings

Patella alta present.

Distally the patellar tendon was avulsed off the attachment to the tibial tubercle.

The gerdys tubercle was avulsed off the attachment to the tibia.

The lateral meniscus was torn from the menisco-capsular attachment to the tibia.

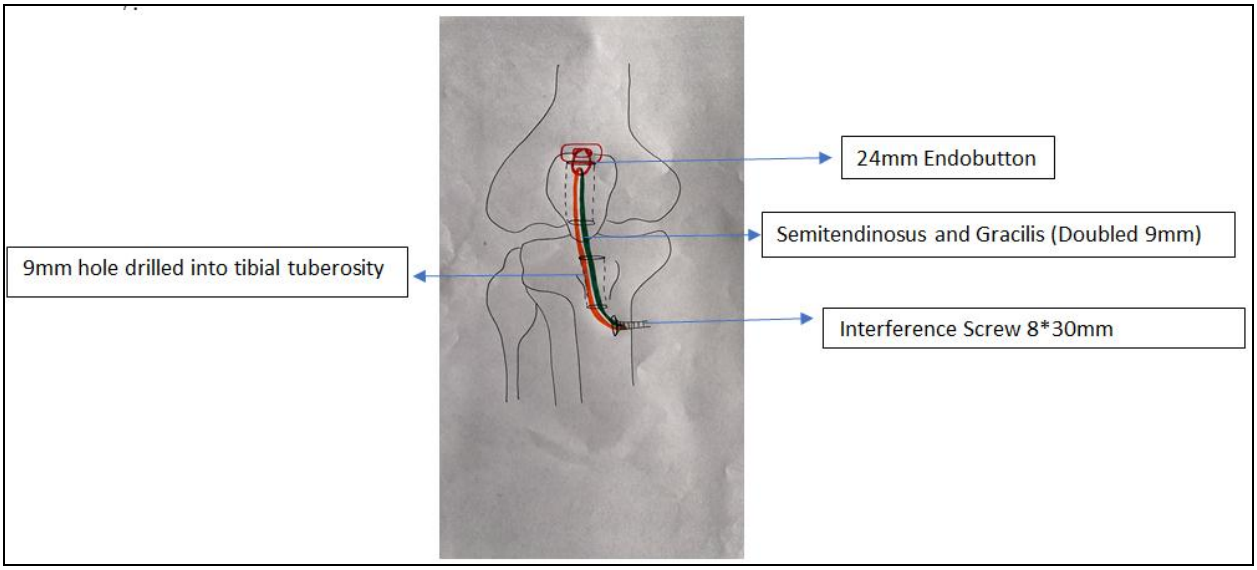
The lateral condyle of the tibia had a depressed fracture. The proximal tibiofibular joint was dislocated.

The common peroneal nerve was explored through a separate incision behind the lateral malleolus. It was traced till it entered the peroneal muscle.

Reconstruction was done as follows

1. Multiple sutures using 1/0 vicryl, no 2 and 5 ethibond were taken through the edge of the lateral meniscus. They were to be tied to the proximal lateral tibial plate.

2. The lateral tibial condyle was elevated through an intra-articular osteotomy entering the joint medial to the tibial spine. It was fixed using 2 mm k wires passed just distal to the joint from lateral to medial.
3. The medial and lateral retinaculum was incised longitudinally so as to bring the distal pole of the patella down to the level of the joint. The tendon stump was trimmed but not excised.
4. The tourniquet was released.
   Bicortical Iliac crest graft was taken from the same side.
   The ST and Gracilis tendons were harvested form the contralateral knee. They were sutured and doubled. Diameter=9mm.
5. The tourniquet was re-elevated. Bone graft was inserted in the defect below the osteotomy and plating done using a proximal tibia plate. The meniscal sutures were tied to the plate.
6. Patellar tendon reconstruction: A beath pin was passed longitudinally from inferior to superior pole of the patella. It was overdrill for the endobutton passage. A 9mm reamer was used for the Semitendinosus and Gracilis graft. Distally a 9mm hole was made at the tibial tubercle from anterior to posterior. Another hole was made from medial to lateral to connect to the first hole. The distal stump of the tendon graft was passed into the proximal hole out through the mediolateral hole. An interference screw (8mmx30mm) was passed into this distal hole, with the knee in 30 degrees flexion and the lower pole of the patella at Blumensat's line.



7. The Gerdys' tubercle was brought down as far as possible and tied to the plate using fibre wire and to adjacent soft tissue.

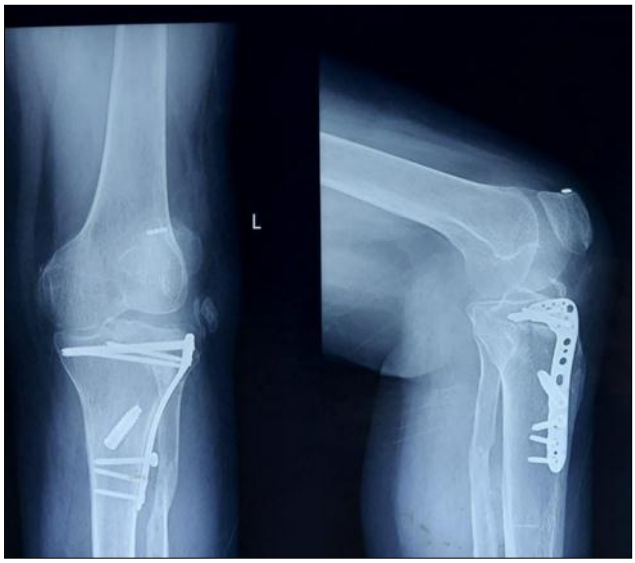


Fig 7: Postoperative xrays: Left to Right: Anteroposterior and lateral views

8. The tourniquet was released, and the wound closed in layers over a drain.
9. Vancomycin and Gentamicin were applied topically on the wound before closure

Rehabilitation Protocol

The patient was kept in an AK Slab for 2 weeks Postoperatively. Following 2 weeks, Isometric Quadriceps and Hamstring Strengthening exercises were started. The

patient was started full weight bearing mobilisation at 3 months. The patient was followed up for 1 year, currently the patient is mobilised without walker with no knee pain, ankle pain. The patient is able to sit crossed leg with no difficulty in long distance walking and climbing stairs.

Fig 8: Left to Right: (A): Limb alignment (B): Knee flexion: 0-120 degrees (C): Range of Motion: Complete Extension at 6 monthly follow up.

Discussion

We represent two managed cases of extensor mechanism injuries of knee for which reconstruction was attempted instead of a secondary repair. Management of neglected cases of extensor mechanism of knee rupture is more demanding as compared to acute fractures. In Patients with Delayed or Neglected fractures, various factors pose challenges in surgical treatment such as adhesion, contracture, retraction with proximal migration of superior pole of patella. In order to counter such problems various methods have been described in literature such as V-Y Plasty of Quadriceps tendon, Quadriceps tendon reconstruction using allograft, Tendon graft augmentation, Pre-operative and Intraoperative traction, Intraoperative traction, Traction over external fixator. Reconstruction of quadriceps tendon is attempted in literature using tendoachilles, hamstrings as biologic scaffold but not much data has been published in the literature regarding reconstruction using Z-plasty and augmentation with a peroneus longus autograft. Benefits of using a Z-plasty: Over and above achieving the desirable length of tendon required for lengthening, the integrity of tendon is maintained. In conventional Z-plasty, the amount of overlapping tissue is limited by lengthening. On the contrary the modified Z-plasty provides almost four times more surface area of tendon tissue overlap. This extra overlap is provides by separation of superficial and deep reins and using it separately for lengthening [1]. Also on leaving the insertions of tendons intact at proximal and distal end, the vascularity of tendon attachment is maintained.

On comparsion of different methods of tendon lengthening, The Z-plasty offered significant increase in length as compared to V-Y Plasty. Also augmenting the Z-plasty with the autograft of peroneus longus tendon lead to augmentation of the soft tissue construct following which early weight bearing and range of motion can be started.

In a study comparing the biomechanical properties of deep flexor tendon from sheep fore limbs, the results obtained concluded that, the Z-Plasty provided significantly greater lengthening followed by the U-T-plasty and then V-Y Plasty. Failure load of the U-T-plasty was 60.7% higher than the Z-plasty and 45.4% higher than the V-Y-plasty. Repairs with the U-T-plasty and V-Y-plasty were significantly stiffer than the repairs with the Z-plasty technique [2].

Often the Z-plasty or Modified Z-plasty have been used for patellar tendon lengthening. Not much literature has been published regarding the quadriceps lengthening using Z-plasty.

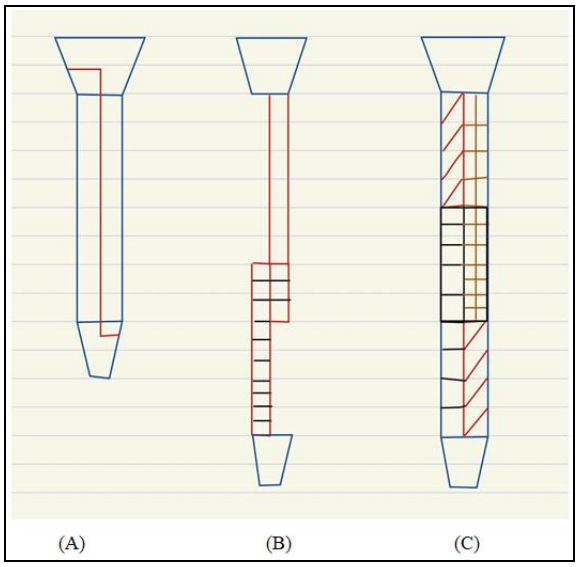


Fig: A comparison between conventional and modified Z-plasty has been shown in the figure.
(A): The red line shows the incision of the Z-plasty and its resulting two reins. (B): In a conventional Z-plasty, the amount of overlapping tendon tissue is limited by lengthening. (C): The modified Z-plasty shows around 4 times more tendon tissue surface area overlap as compared to conventional Z-plasty due to two superficial and two deep reins.

Conner *et al*. described a technique for managing a patient with chronic quadriceps tendon rupture where V-Y Plasty was done to bride the segmental tendon gap. This was followed by using Achilles tendon as a biologic scaffold that assisted in reconstituting the strength of the construct [1].

Mandelbaum *et al*. recommended Z lengthening for the quadriceps tendon and Z shortening for the patellar tendon with augmentation using the semitendinosus and gracilis tendons. They applied a cylinder cast for the first two weeks with the knee in full extension and progressively increased the amount of flexion (10 degrees/week) in a hinged knee brace. They reached 90° of active flexion at 10 weeks and 130° at the one-year follow-up [4].

Chen *et al* provided a description of method in a case report of 2 patients who underwent a delayed patellar tendon reconstruction using gracilis and semitendinosus tendons combined with a tension reducing wire. This technique corrected the patellar height to allow for maximal range of motion, and both patients had good results with no evidence of extensor lag.

This technique was different from ours due to the fact that the tibial insertion of semitendinosus and gracilis was retained, hence the added advantage this provided was avoiding the potential benefit due to absence of avascular necrosis which occurs as a result of complete detachment, hence it increases the viability [5].

Cusanos *et al*. reported a patient with inferior pole of patella fracture who has Quadriceps contracture and migration of proximal fragment. A single step surgery was performed where inferior patellar pole excision with Z-plasty for Quadriceps Lengthening, Patellar tendon reconstruction with achilles tendon autograft and hamstring tendon autograft and human acellular dermal matrix augmentation. The 2 year follow up showed stable patella with no pain and improved IKDC & tegner activity level scores. Patellofemoral arthritis was reported as a problem due to Z-Plasty [6].

Ayas *et al*. in his case series of 2 cases of Extensor mechanism reconstruction using a peroneus longus tendon autograft for neglected patellar fracture reported excellent functional outcome based on The International Knee Documentation Committee (IKDC) and Tegner-Lysholm scores which were 33 and 32.2 in the preoperative period and 86 and 86.4 in the postoperative period respectively. For Patient 2, The IKDC and Tegner-Lysholm scores were 29 and 28, 7 in the preoperative period and 88 and 86.2 in the postoperative period respectively [7].

Often the peroneus graft has been used in literature for ACL reconstruction. Following its removal there is no difficulty in performing ankle movements and walking. In another study it has been told that removal of peroneus longus graft has no effect on gait parameters and does not result in walking instability [8].

Conclusion

Extensor mechanism injuries are often devastation with poor functional outcome. The authors have reported a successful reconstruction of Quadriceps tendon using Z-plasty and augmentation with a peroneus longus autograft. In the other case patellar tendon reconstruction was carried out using Semitendinosus and Gracilis autograft. These cases followed up for a period of 13 months presented with excellent functional outcome with good range of motion at knee joint.

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