Why Do Patellofemoral Stabilization Procedures Fail? Keys to Success

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Abstract:

In recent years, surgical interventions for patellofemoral joint instability have gained popularity, possibly revitalised by the recent advances in our understanding of patellofemoral joint instability and the introduction of a number of new surgical procedures. This rise in surgical intervention has brought about various complications. In this review article we present the complications that are associated with five main surgical procedures to stabilise the patella – medial patellofemoral ligament reconstruction, tibial tubercle osteotomy, trochleoplasty, lateral release/lateral retinacular lengthening, and de-rotation osteotomies. The key to success and potential problems with these surgical techniques are highlighted in the form of “expert takeaways”.

Keywords: Patellofemoral Instability; Complications; Medial Patellofemoral Ligament, Trochleoplasty; Lateral Release; Tibial Tubercle Osteotomy

Introduction

The etiology of patellofemoral (PF) instability is multifactorial; the most common contributing factors are either dynamic (functional), such as hip abductor or VMO weakness, tight lateral retinaculum, tight Iliotibial band (ITB), or static (anatomic), such as valgus and high quadriceps (Q) angle, patella alta, high tibial tuberosity-trochlear groove distance (TT-TG), excessive femoral anteversion, external tibial torsion, and trochlear dysplasia [1]. Surgery for PF instability has received great attention in recent years and the failure of procedures and complications are still relatively common. The most popular and concomitant procedures for patellar instability are medial patellofemoral ligament (MPFL) reconstruction, lateral retinacular lengthening, tibial tubercle osteotomies (TTO), de-rotation osteotomies, and trochleoplasty [2, 3]. The isolated lateral release procedure is known to yield unpredictable outcomes, yet it remains a common procedure performed by non-expert patellofemoral surgeons [4].

Patellofemoral surgery remains challenging due to the number of variables that can affect the outcome. As such, correction of the instability requires a tailored assessment of the individual and simple algorithms can sometimes be unhelpful. The key for successful patellofemoral stabilization is a comprehensive assessment of all the contributing factors to the instability to allow the correct surgical correction of the problems identified. Patellofemoral instability is multifactorial, as highlighted in previous studies that have shown some measures of PF instability are not necessarily correlated with each other (e.g. Q angle vs TT-TG) (1) or show any difference between symptomatic and asymptomatic knees (e.g. TT-TG) (2). Understanding of patellofemoral biomechanics and limb alignment is very important. The purpose of this review article is to understand the pearls of PF stabilization surgery, and how to reduce complications and prevent failure of PF stabilization procedures. For each surgical procedure discussed, the review will present a selection of "keys to success: expert takeaways" to help decision making and techniques in patellofemoral stabilization surgery. For a more detailed review of current concepts in patellofemoral instability, see Kader et al. (3).

Medial Patellofemoral Ligament Reconstruction

The MPFL is considered the primary medial restraint of the patella within a flexion range of 0-20 degrees (4), contributing up to 60% of the restraint to lateral patella displacement (5). Medial patellofemoral ligament reconstruction (Figure 1) is the most common procedure for PF instability; it can be performed through many different techniques (6, 7). The most common complications of MPFL surgery come from improper femoral tunnel placement, over-tensioned graft, and patellar fractures (6-9). Minor technical errors in MPFL reconstruction can lead to dramatic increases in medial PF cartilage force and pressure (10). The femoral fixation point during MPFL reconstruction remains a highly debated issue. A mal-positioned femoral tunnel, either proximal or distal to the anatomic location of the MPFL attachment (Figure 2), leads to a significant increase in the contact pressure through the medial joint, as well as medial translation of the patella (11, 12). The kinematics of the patella were not ideal when using a smaller and tubular graft in comparison with the native wide and fan-shaped MPFL (13). In patients with TT-TG distances up to 15 mm, MPFL reconstruction can restore patellofemoral kinematics and mechanics, However, for patients with TT-TG distance more than 20 mm, isolated MPFL reconstruction is less likely to correct the problem and a tibial tubercle osteotomy (TTO) may be indicated (14). In fact, patients with lower TT-TG have been shown to have better outcomes in terms of Kujala score compared to those with higher TT-TG following MPFL reconstruction using an anatomic femoral tunnel site (15).

A number of complications from MPFL reconstruction surgery can arise. Patellar fractures have been reported with differing fixation techniques (16, 17). In addition, a mal-positioned femoral attachment can overstress the patella and contribute to patella fractures (18). Two cases of patellar fracture were reported after MPFL reconstruction using suture anchors although the tunnels do not traverse the whole the patella (16).

Keys to Success: Experts Takeaways

- Avoid isolated MPFL reconstruction in patients with significant patella alta or high grade trochlea dysplasia. It is important to correct the bony problem in such cases and not rely on a soft tissue procedure to do so.
- Use intraoperative fluoroscopy to check femoral tunnel position (Figure 3).
- Ensure fixation on patella remains in the top half of the patella and avoid excessive use of hardware.
- Perform an intraoperative check of graft isometry to ensure no significant tightening of graft occurs as the knee moves into extension. Over tightening of graft as knee flexes can result in a loss of knee flexion and high forces through the medial patella facet (11, 18).
- The MPFL acts as a checkrein to lateral translation of the patella and it does not pull the patella into the trochlear groove (19), hence the the term “tensioning the graft” should be avoided (20).

- Fix the graft at the furthest point between attachment sites with the knee flexed within the range 40-60 º (21).
- Fractures can be minimized by avoiding tunnels traversing across the whole patella or through securing graft by suture anchors instead of an endobutton or screw (20).
- Patellar fractures can be avoided by different ways of patellar attachment which are described as follows:
    - Using a gracilis autograft to be sutured to soft tissue without bone tunnel (22).
    - Using the docking technique for medial patellofemoral ligament reconstruction (23).
    - Using the medial quadriceps tendon femoral ligament (MQTFL): the graft is secured through and into the distal medial quadriceps tendon just above the patella (sparing the patella bone) (24).

Tibia Tubercle Osteotomy

Tibial tubercle osteotomy is a useful operation for patella instability in cases of significant patella alta or significantly increased TT-TG or tibial tuberosity-posterior cruciate ligament (TT-PCL) distance, but complications can arise. Tibial fracture is a concern; Stetson and Fulkerson et al reported a tibial fracture rate of 8-11% by allowing patients to weight bear as tolerated (25). Cosgarea et al stated that oblique osteotomies are less liable to failure than flat osteotomies and they emphasized that greater cross-sectional involvement of the tibia can be secured with greater obliquity (26). Non-union at the site of the osteotomy has been reported, however, it is a rare complication of TTO. The level of correction is a critical determinant for PF stabilization; overcorrection with an anteromedialization (AMZ) osteotomy can generate pain through producing higher forces on proximal and medial parts of the patella (27). Like any osteotomy it is important to plan the exact correction.

Keys to Success: Expert Takeaways

- Limit AMZ indication to cases with elevated TT-TG associated with distal lateral chondrosis of the patella (28).
- When anterization is needed, adhere to the range from 10-15 mm (29).
- When medialization is needed, avoid over-medialization in way to normalize TT-TG up to 15 mm (30).
- Limit distalization to significant patella alta (31).
- Taper the distal part of the osteotomy, avoid breaching the posterior cortex of the tibia (32).
- Pay attention to the post-operative rehabilitation and allow protected weight bearing for 6 weeks after TTO (32, 33).
- Avoid placing the screws at the periphery of the shingle; this can mitigate shingle fracture risks (33).
- Avoid tibial tubercle transfer in cases of medial or proximal PF chondrosis (34).

Trochleoplasty

Trochleoplasty surgery is increasing in popularity as it seems to be a logical treatment option. Techniques have evolved over time. Albee described a technique of elevation of the lateral trochlea facet in 1915 (35). Two main techniques have become established over recent years: the thick flap technique and the thin flap technique (36-38). Trocheloplasty is indicated when significant dysplasia of the trochlea groove (Figure 4) causes the patella to dislocate often over a prominent lateral bump (39, 40). Trochlear dysplasia is critical contributing factor in patellar instability and managing the patellofemoral joint. Often, additional procedures are required with trochleoplasty surgery. This can consist of MPFL reconstruction, lateral lengthening, tibial tuberosisty transfer or a combination of operations (41, 42). Stiffness post surgery can be a problem. Donell et al reported on 17 knees that underwent deepening trochleoplasty, five patients (33%) needed arthroscopic arthrolysis 6 weeks after operation (43).

Keys to Success: Expert Takeaways

- Consider TT-PCL in cases with marked dysplasia; TT-PCL could be more valuable than TT-TG in such cases; 57% of patients with TT-TG $\geq$ 20 mm corresponds to TT-PCL $\geq$ 24 mm (44).
- The indication of trochleoplasty should be limited to Dejour Grade B and D trochlear dysplasia with patellar instability (32, 36, 37). Avoid trochleoplasty in cases with open physes and diffuse patellofemoral arthritis (38).
- Surgery is complex and, as such, should only be performed by surgeons with expertise in this area.
- Thin flap technique is technically challenging particularly in cases with a large lateral bump care is needed to avoid perforation into the joint on the medial side.

Lateral Release and Lateral Retinacular Lengthening

Historically, lateral retinacular release (Figure 5) was the most common procedure for PF instability, however, inconsistent results were reported with poor improvements in pain and function (45, 46). Recent studies show that isolated lateral retinacular release is not a recommended procedure for PF instability and it has a very limited indication. The members of the International Patellofemoral Study Group reported that isolated lateral release is now rarely performed (47). Medial patellar subluxation is the biggest possible complication of isolated lateral release (45). In such cases, Sanchis-Alfonso et al demonstrated better outcomes in function and pain relief in their series of 17 cases after lateral retinacular reconstruction (46). Lateral retinacular lengthening gives superior outcomes for PF instability and it is highly adopted by many PF experts nowadays. Fulkerson and Shea recommended that lateral release has little role and when indicated, and release of retinaculum should not be done beyond the proximal pole of the patella to keep the attachment of vastus laterals obliquis attachment (48).

Keys to Success: Expert Takeaways

- Avoid isolated lateral retinacular release, however, it might be useful in lateral patellar tilt or lateral patella compression syndrome.
- Lateral retinacular lengthening is a reliable procedure and has superior outcomes.

De-rotation Osteotomies

When assessing any patient with PF instability, the lower limb alignment and rotation should be considered as a whole. Any PF stabilization procedure is doomed to fail if the rotational abnormalities of the tibia and femur ignored. A number of studies have investigated the relationship between PF instability and femoral neck anetversion and/or external tibial torsion. External tibial torsion has been reported by a number of studies to be increased above normal ranges in patients with PF instability (49-52). Fouilleron et al concluded that medialization of the tibial tubercle was not sufficient to restore PF stability in patients with excessive external tibial torsion (49). Instead, they recommended a tibial de-rotation osteotomy, for which they reported excellent outcomes and improved PF stability. A number of other authors have also suggested that excessive external tibial torsion must be corrected to achieve satisfactory results in restoring PF stability (53-57). Cameron and Saha further reported the best outcomes following Maquet type osteotomies in those patients reduced preoperative symptoms of pain (52). In our own retrospective analysis of 60 patients with recurrent unilateral PF instability (42 male, 18 female, aged 25 ± 9 years), no difference was observed in external tibial torsion between symptomatic and asymptomatic knees, although the mean is above that suggested as being pathological in both symptomatic and asymptomatic knees (Figure 6). This would suggest that in patients with unilateral instability, an excessive external tibial torsion may not be the main underlying factor contributing to PF instability. A small number of complications have been reported, including nerve palsy (49, 58), valgus deformity (58), distal physeal closure (59), and delayed/non-union (58-60). Complications have been typically found in less than 15% of patients which have, in some cases required revision surgery. Despite some studies reporting delayed/non-union following tibial de-rotation osteotomy (58-60), Fouilleron et al reported full union in all patients included in their study (49).

Kaiser et al reported no relationship between increased femoral neck anteversion and PF instability in a canine model (61). Whilst abnormal femoral neck anteversion has been associated with anterior knee pain (62) and osteoarthritis of the knee and hip (63, 64) in humans, Reikeras observed no relationship between increased femoral neck anteversion and patellofemoral characteristics such as the sulcus angle, congruence angle or lateral PF angle, suggesting that it is not linked to PF instability (65). Similarly, in 12 patients with "inwardly pointing knees" with symptoms suggesting they had PF instability, Cooke et al reported that femoral neck anteversion was not related to the malalignment seen in the knee (66). In the same retrospective analysis shown in Figure 6, of patients with recurrent unilateral PF instability, no difference was observed in femoral neck anteversion between symptomatic and asymptomatic knees (Figure 7). This would appear support the previous findings suggesting no link between femoral neck anteversion and PF instability, or at least point to the multifactorial nature of PF instability.

Keys to Success: Expert Takeaways

- Consider tibial de-rotation osteotomies in combination with other PF stabilizing procedures where there is excessive external tibial torsion.
- Pay careful attention to the interpretation of external tibial torsion in patients with recurrent unilateral PF instability. If the femoral neck anteversion or external tibial torsion is the same in symptomatic and asymptomatic knees, it could point to there being some other main underlying cause of the PF instability.
- Whilst there is limited literature investigating the link between femoral neck anteversion and PF instability, there has been no demonstrated relationship between

them, to date. This might suggest that femoral de-rotation osteotomy is not an appropriate surgical procedure in the management of PF instability.

- De-rotation osteotomies are highly invasive procedures. Whilst malalignment at the knee could be corrected by either single or double derotation osteotomies, less invasive procedures such as MPFL reconstruction can often be successful in correcting patellofemoral instability (67).

Conclusion

The etiology of patellofemoral instability is multifactorial and a complex issue to understand. Surgeons need to perform a comprehensive examination of the patellofemoral joint and the overall lower limb rotational alignment. Surgical decision making in patellofemoral stabilization requires the knowledge and expertise of the PF joint mechanics and trochlear dysplasia. Isolated MPFL reconstruction should be limited to cases without bony malalignment. The MPFL acts as a checkrein to lateral translation of the patella and it does not pull the patella into the trochlear groove. Therefore, surgeons should not use excessive tension on the patella when reconstructing the MPFL. Trochleoplasty is a technically demanding procedure and indicated in high-grade trochlear dysplasia. Trochleoplasty should be combined with other procedures if necessary to restore patellar stability. Further investigation and long term follow up is needed for trocheoloplasty. De-rotation osteotomies of the tibia have been shown to improve PF stability, although no studies have reported on the effectiveness of femoral de-rotation osteotomy in patients with increased femoral neck anteversion on PF stability.

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Figure captions

Figure 1. Reconstructed MPFL prior to femoral attachment

Figure 2. Illustration of the femur showing Schottle's point and the anatomic point for femoral tunnel positioning during MPFL reconstruction

Figure 3. Femoral tunnel placement in MPFL reconstruction under X-ray guidance.

Figure 4. Example of severe dysplasia requiring trochleoplasty

Figure 5. Arthroscopic images during a lateral retinacular release

Figure 6. External tibial torsion in 60 patients with recurrent unilateral patellofemoral instability

Figure 7. Femoral neck anteversion in 60 patients with recurrent unilateral patellofemoral instability

Figure 1

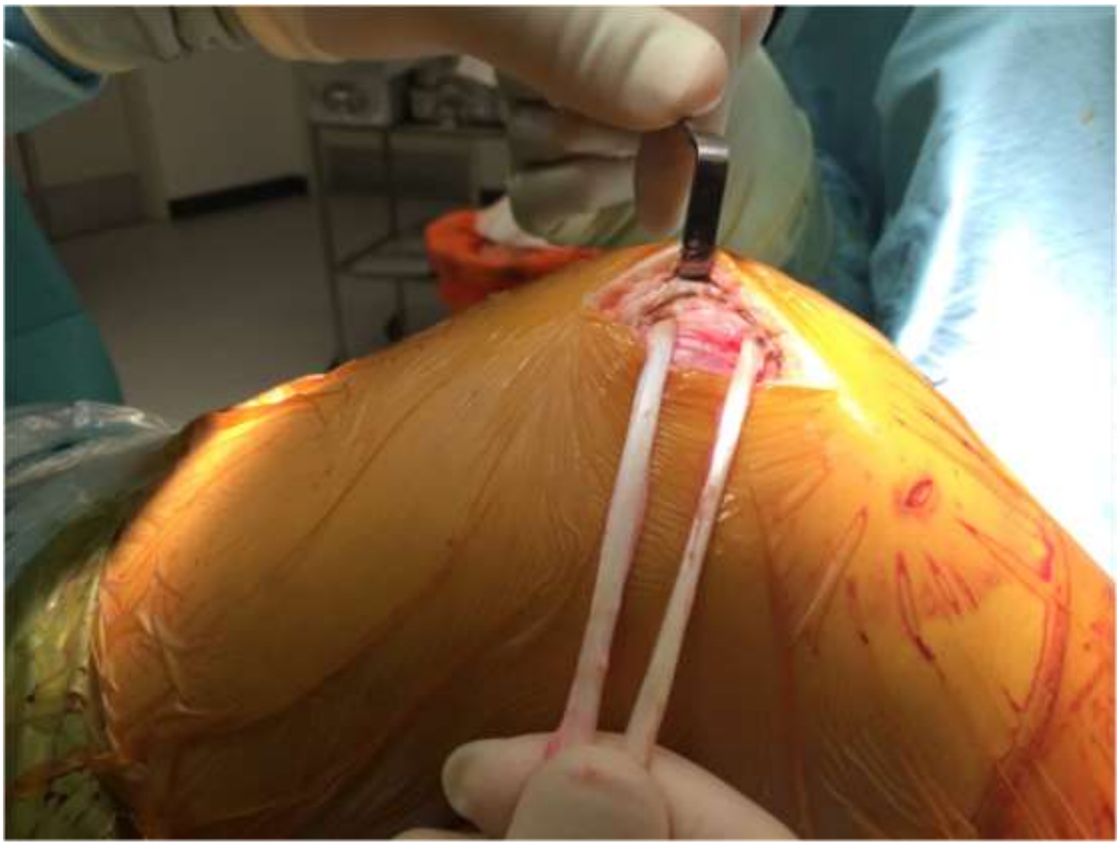

Figure 2

Figure 3

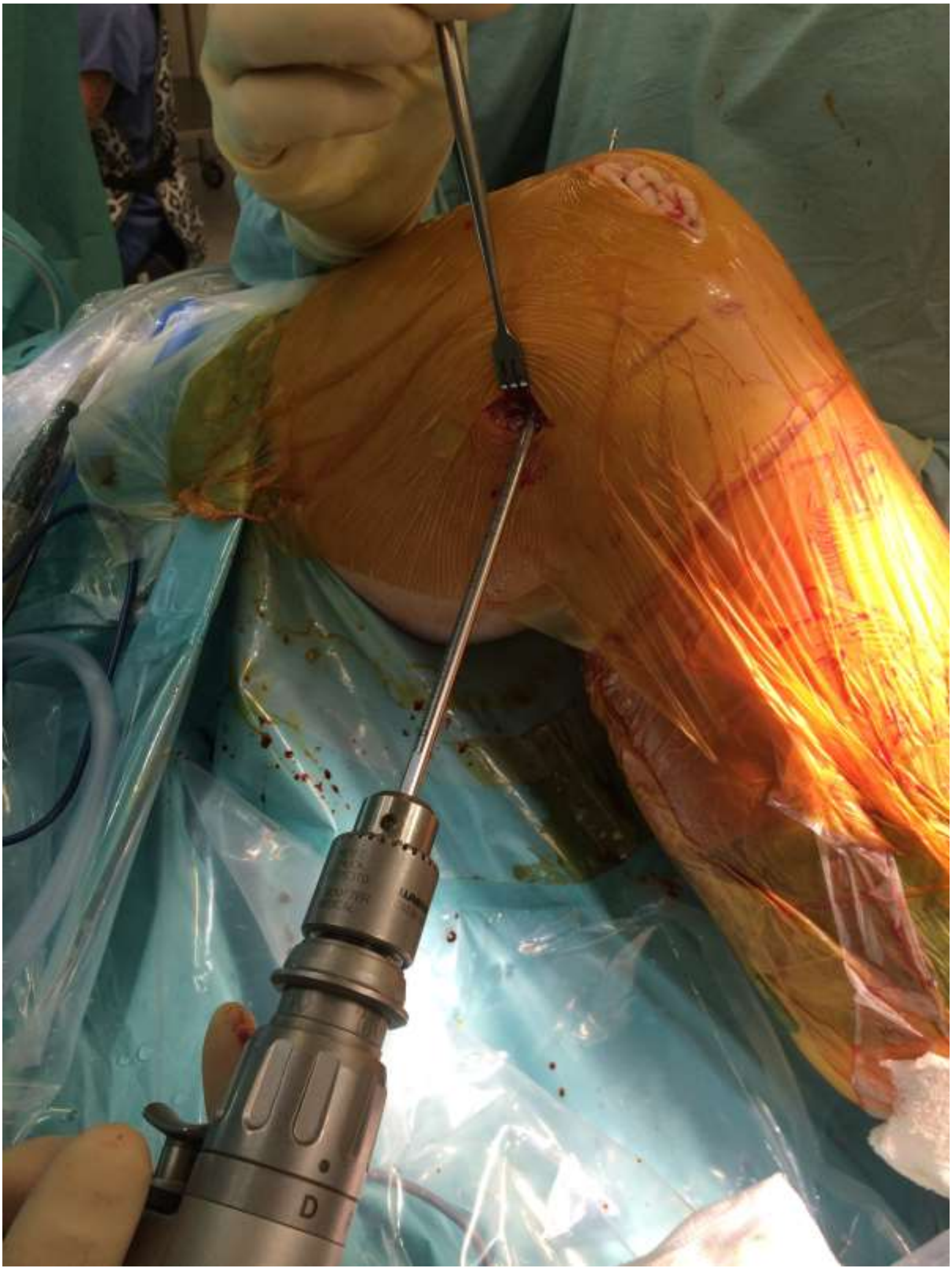

Figure 4

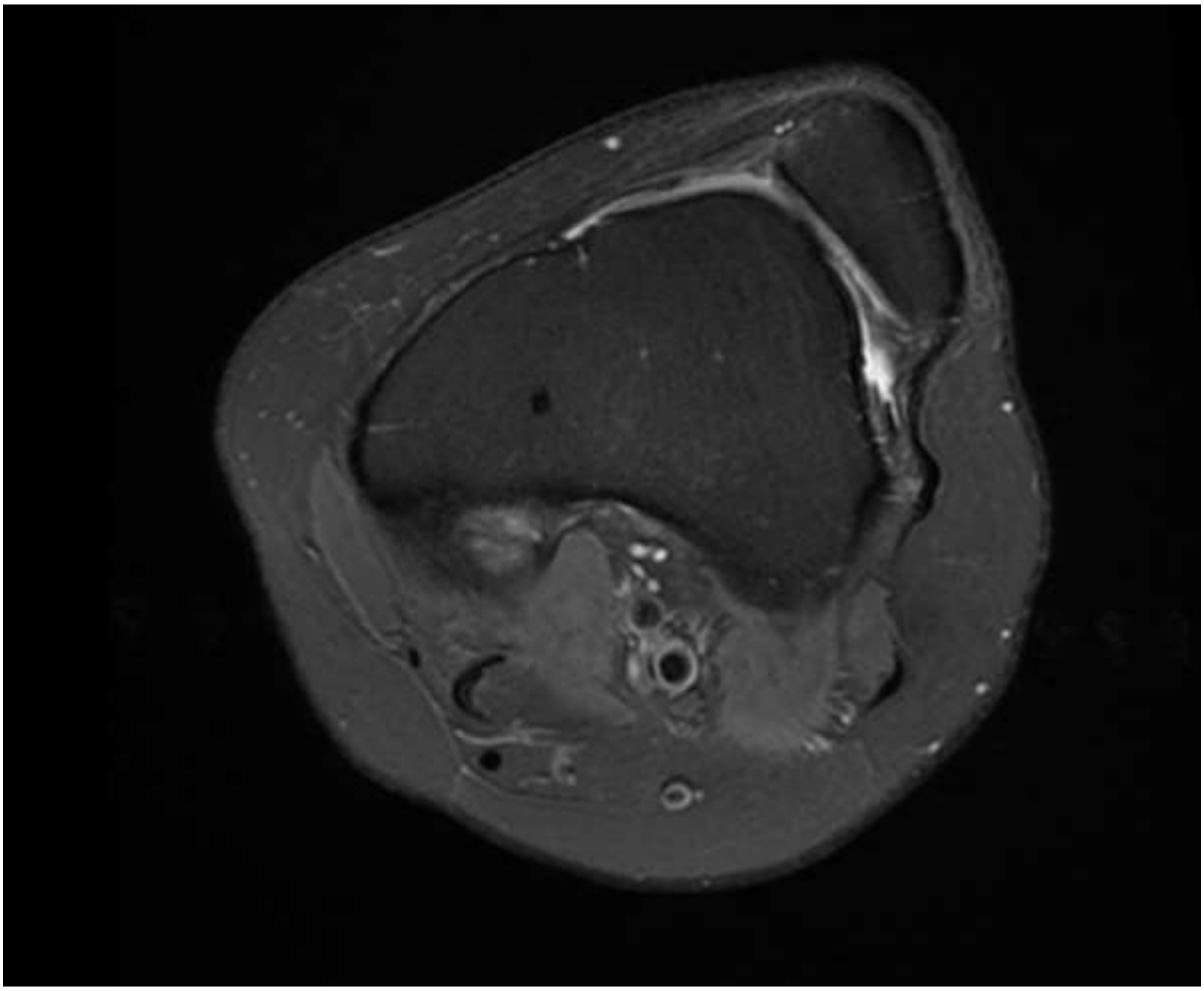

Figure 5

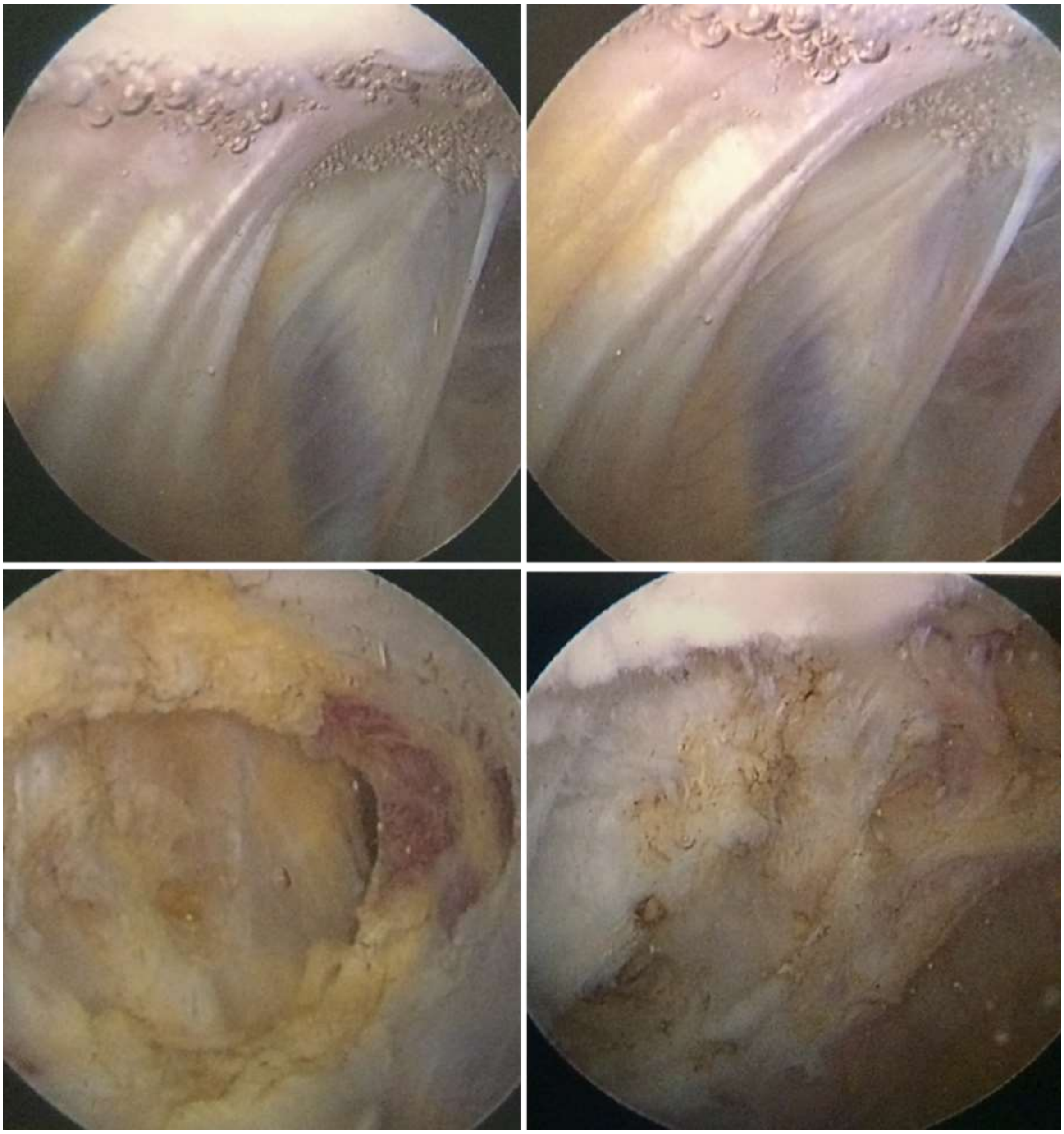

Figure 6

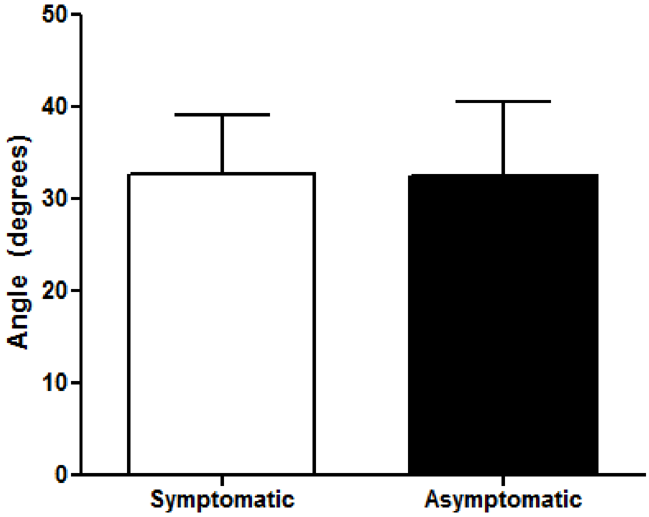

Figure 7