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Minimally Invasive Medial Patellofemoral Ligament Reconstruction For Patellar Instability Using An Artificial Ligament: A 2 Year Follow-Up

Running Title

Minimally Invasive MPFL Reconstruction

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- None

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Statement of Location

- The study was undertaken at Associate Professors M. Al Muderis's clinics, situated at Norwest Private Hospital

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Key Words

- Medial patellofemoral ligament; Reconstruction; Artificial Ligament; No Bracing

Abstract

Introduction

Recurrence of acute patellar dislocation affects approximately 30% of individuals, and up to 75% of those with grade IV instability. The medial patellofemoral ligament (MPFL) is considered to be critical for patella stabilisation. MPFL reconstruction with allografts has been proposed to reduce risk of recurrence, but there is limited evidence about the safety and effectiveness of techniques using synthetic allografts.

Method

We present a retrospective case series of 29 individuals who underwent a MPFL reconstruction between 2009 and 2012, using an artificial ligament for patellar instability by a single surgeon. Clinical, radiological and functional outcomes were measured at a minimum of 24 months.

Results

31 knees (29 individuals) were followed up for a median of 43 (range: 24 – 68) months. Using the Crosby and Insall grading system, 21 (68%) were graded as excellent, 9 (29%) were good, 1 (3%) as fair and none as worse at 24 months. The mean improvement in Lysholm knee score for knee instability was 68 points (standard deviation 10). Ligamentous laxity was seen in 17 (55 %) of individuals. In this subset, 12 were graded as excellent, 4 as good and 1 as fair. The mean improvement in patellar height was 11 % at 3 months follow-up. All knees had a stable graft fixation with one re-dislocation following trauma.

Conclusions

We propose a minimally invasive technique to reconstruct the MPFL using an artificial ligament allowing early mobilization without bracing. This study indicates the procedure is safe, with a low risk of re-dislocation in all grades of instability.

Word Count – 249

Keywords

Patella; Medial patellofemoral ligament; Reconstruction; Artificial Ligament; No Bracing

1. Introduction

Acute patellar dislocation frequently leads to recurrence. A systematic review of trials of reconstruction techniques versus conservative rehabilitation reported the rate of re-dislocation after a conservatively managed primary patellar dislocation ranged from 19 - 54 % (5 trials, 339 patients) [1]. This risk is higher in patients with ligamentous laxity, with one retrospective single centre series of 104 individuals treated for patellar dislocation reporting an overall recurrence after an acute dislocation of 30 %, and 75 % in the subgroup (n = 66) who had ligamentous laxity and abnormal patella position [2].

Various surgical methods have been described in the literature to treat lateral patella dislocation [3-8]. Surgical procedures used in Europe have been founded on strict radiographic guidelines, that is, ‘‘le menu a `la carte’’, where all the instability factors are individually corrected [9]. However, the importance of correcting each of these instability factors, alone or in combination is uncertain [9]. There is also uncertainty about the safety and effectiveness of current standard procedures. The above mentioned systematic review comparing surgical repair with conservative rehabilitation in a total of 339 patients with dislocation found no robust evidence of improved clinical (pain, range of motion) or functional (Kujala scores) outcomes in individuals managed with surgical repair [1]. Apart from recurrent dislocation, common post-operative complications reported in the literature are persistent patellofemoral instability, patellofemoral osteoarthritis, loss of flexion, medial subluxation, stiffness and chronic knee pain [1, 3, 7, 8, 10].

The importance of the medial patellofemoral ligament (MPFL) was first described in the late 1950’s [11]. A cadaveric study on 25 specimens determined that, biomechanically the MPFL provides 53 % of the lateral stabilizing force [12]. It is consequently the most important medial soft-tissue restraint and has been shown to be consistently injured after a patellar dislocation [4]. Brückner was the first to present a technique of transferring the medial part of the patellar ligament to the medial epicondyle to stabilize the patella [13]. But only recently with the evolution of shoulder surgery there has been an increased focus on reconstruction of the MPFL.

Several techniques have been described to reduce the high incidence of recurrent dislocation with encouraging clinical results [8].

Numerous sources have been used to reconstruct the MPFL including semitendinosus, semimembranosus, gracilis, quadriceps, vastus medialis retinaculum, or artificial tendons [3, 8, 14-16]. In 1992, Ellera was the first to describe MPFL reconstruction with an artificial polyester ligament in 30 patients fixed by tunnel fixation on the patella and sub-fascially to the medial femoral condyle [17]. At a minimum of 24 month follow-up, 25 (83%) patients showed improvement with a Crosby and Insall grade of good-excellent [17]. The use of synthetic material is appealing to avoid the morbidity associated with other allograft choices [16]. However, there have been very few other articles describing techniques using synthetic allografts. Nomura et al (2000) have recently reported a 5 year follow-up study of 27 patients treated with MPFL reconstruction with an artificial polyester ligament with staple fixation at the femoral condyle, with 26 (96 %) reporting good to excellent outcomes using the Crosby and Insall grading system[5]. But other cohort studies reporting on the use of the artificial ligament question its safety in view of late graft failure, risk of late infection, stiffness, inflammation and cost effectiveness subsequent to use of synthetic allografts [15, 16].

The purpose of our study is:

1. To describe a minimally invasive arthroscopically assisted technique to reconstruct the MPFL using a synthetic allograft.
2. To describe our post-operative rehabilitation protocol.
3. To present data on safety and benefits of the surgical procedure in patellar instability especially in patients with predisposing factors.

2. Patient & Methods

2.1 Study Design & Setting

We retrospectively reviewed all individuals who underwent a MPFL reconstruction using an artificial ligament (LARS Ligament, CORIN Ltd, Mersilene Tape MT, or AchilloCord^{PLUS} Ligament, Neoligaments Ltd) for patellar instability by a single surgeon between 2009 and 2012 who had completed 24-month follow-up. Each case was treated at a specialized orthopaedic knee clinic run by the investigators. The University Human Research Ethics Committee and hospitals where the study was conducted approved the study.

All individuals underwent a screening interview and examination to determine their eligibility using the criteria listed in Table 1. Pre-operative assessment included a thorough history, physical examination and radiological evaluation. Patients were assessed for passive patellar hypermobility, mal-tracking, apprehension, knee range of motion and a Clarke test as a part of the physical examination [18]. Generalized ligamentous laxity was scored using the Wynn Davies criteria [19] and classified using the method established by Runow et al [2]. The Lysholm knee scoring scale was administered to assess the functional impairment due to clinical instability and evaluate the outcomes of knee ligament surgery [20, 21]. Plain x-ray (antero-posterior, lateral & skyline view) examinations and Magnetic Resonant Imaging (MRI) scans were performed to assess the integrity of the MPFL, chondral damage ,internal derangement and the position of the tibial tuberosity. The procedure was recommended for individuals with a torn/attenuated MPFL who had symptoms such as giving way, instability, & mal-tracking that did not ameliorate after 3 months of conservative therapy including quadriceps muscle strengthening (Table 1).

Table 1 – Inclusion / Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Torn/Attenuated Medial Patello-femoral Ligament	Intact Medial Patello-femoral Ligament
Recurrent Patellar Dislocation Refractory to Conservative Treatment > 3 months	Instability in Presence of Moderate-Severe Patello-femoral Arthritis
Pathological Ligamentous Laxity	History of Previous Surgery

2.2 Outcome Measures

Clinical outcomes included pain level, knee range of motion, passive patellar hypermobility, mal-tracking & apprehension at follow up [3]. Plain x-rays were used to measure the sulcus angles & the patellar height (Insall-Salvati index) at baseline & 3-month follow up [3]. X-Rays were also performed at 6, 12 months and yearly follow-up to assess the integrity of the fixation (alignment, positioning) and other complications (arthritis, fracture). Adverse events including re-dislocation, prominence of the graft, and knee stiffness were monitored. All outcomes were measured by a single investigator and confirmed by a senior surgeon.

Functional outcomes were assessed using the Lysholm knee scoring scale to measure symptoms in the knee at baseline and yearly follow-up [20]. The Crosby and Insall grading system was used to assess outcomes following ligament reconstruction. Using this system, outcomes were classified into four categories (Excellent, Good, Fair to Poor & Worse) [22].

2.3 Surgical Technique

A two-step surgical procedure was performed including a knee arthroscopy followed by reconstruction of the MPFL using an artificial ligament.

Patients underwent general anaesthesia. Prophylactic intravenous antibiotics using 1 gram of Cephazolin was administered. Positioning and draping was similar to a standard knee arthroscopy. The knee was first examined & the tightness of the lateral structures was assessed. Following this a knee arthroscopy was performed using standard antero-medial & antero-lateral portals to visualize the knee, remove any loose bodies and deal with any other intra-articular pathology (e.g. chondroplasty for chondral wear). The lateral retinaculum was released arthroscopically using thermal ablation in all patients.

The Through Tunnel Technique was used to achieve fixation for the artificial ligament [23]. A 2 - 3 cm vertical skin incision was made over the lateral upper half of the patella. Under image intensifier a 3.2 mm tunnel was drilled over a guide wire through the junction of the upper third and the lower two thirds of the patella (Figure 1). A wire was then passed through the patellar drill hole. A 1 cm incision was made over the medial condyle at the natural attachment of the MPFL through which the wire was pulled medially using long forceps in the middle layer of the soft tissues, just superficial to the capsule. Through the same incision, a second 3.2 mm tunnel was made at the isometric insertion site of the MPFL (1 mm anterior to the extension line of the posterior cortex and just proximal and behind the attachment of the superficial part of the medial collateral ligament), along the epicondylar axis of the femur [3, 24]. For skeletally immature patients, the tunnel was accurately positioned in the epiphysis to avoid injury to the growth plate [3]. The artificial ligament was then prepared by folding it over itself and passing an endobutton at one end to secure the fixation at the lateral border of the patella. A wire passer was utilized to thread the ligament through the patella and the femur. The ligament was now tensioned with the leg in full extension. Subsequently, the knee was positioned in full flexion, without engaging the ligament at the lateral femoral cortex. Femoral fixation was then achieved using a 7 mm interference peek screw, which was inserted through the lateral incision (Figure 2, 3). This avoided over loosening or over tightening of the artificial ligament. The knee was then taken through a range of motion to check tracking and patellar stability.

The tibial tuberosity – trochlear groove (TT-TG) distance was measured using superimposition of axial slices on MRI [25] for all the patients and if the distance was more than 15 mm and patella mal-tracking persisted after the MPFL reconstruction, a medialization procedure for the tibial tuberosity was performed. This involved a separate 2 – 3 cm vertical incision centering over the tibial tuberosity. Under image intensifier guidance an osteotome was used to elevate the tibial tuberosity and realign it. Fixation was attained by use of 2 standard AO screws under image intensifier guidance. Final x-rays were then taken and the wound was closed in layers. No knee immobilizer was used post-operatively.

Figure 1 – Patellar Tunnel

a. Clinical Image b. X-ray Image

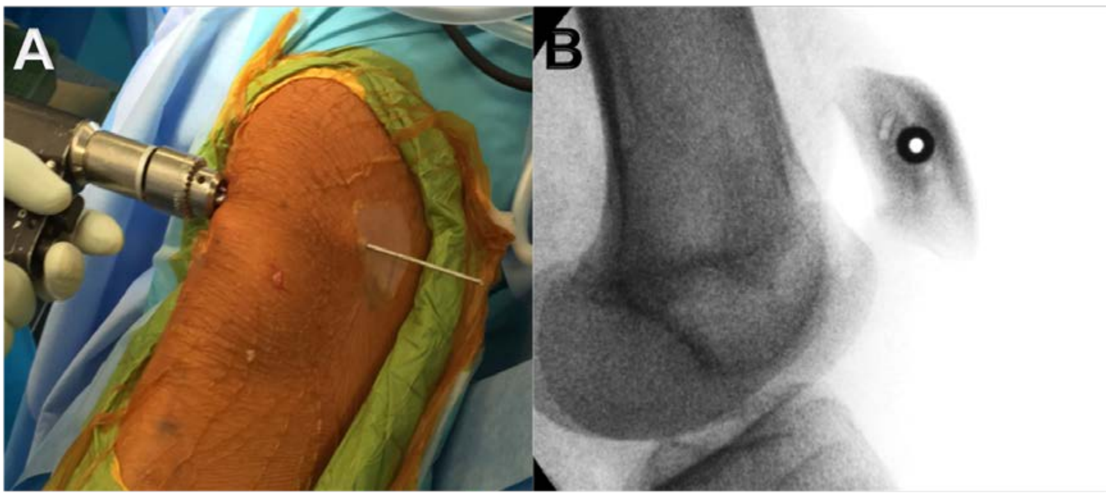


Figure 2 – Graft Construct

a. Artificial Ligament, b. Endobutton, c. Interference Screw, d. Through Tunnel Technique

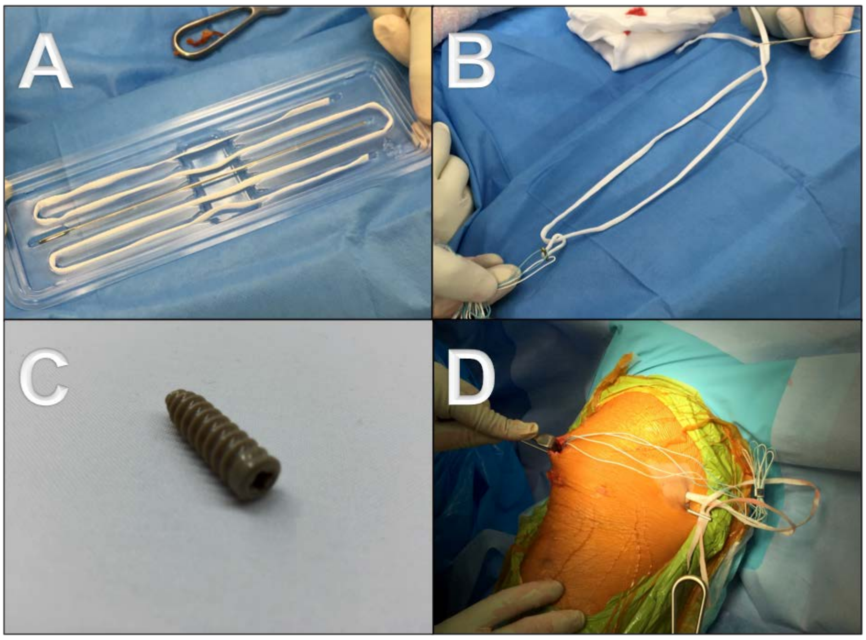
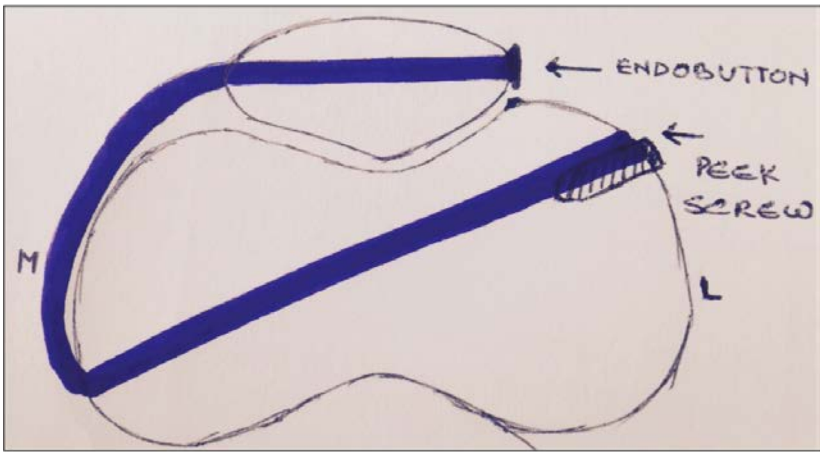


Figure 3 – Final Graft Position



2.4 Post-operative Management

Immediately after surgery no brace was applied. Patients had an overnight hospital stay. The post-operative protocol is shown in Table 2. Quadriceps rehabilitation was started on the first post-operative day with the knee in extension and the patients were allowed to mobilize weight bearing as tolerated using crutches. They were discharged on oral analgesics. The passive knee range of motion was started in the 1st week by a physiotherapist. At one week, the wounds were checked and the integrity of fixation was formally confirmed using plain x-rays (Figure 4). Jogging and non-impact sports activities were permitted at 8 weeks and full sports activities at 12 weeks.

Figure 4 – Plain X-rays a. Antero-posterior b. Lateral

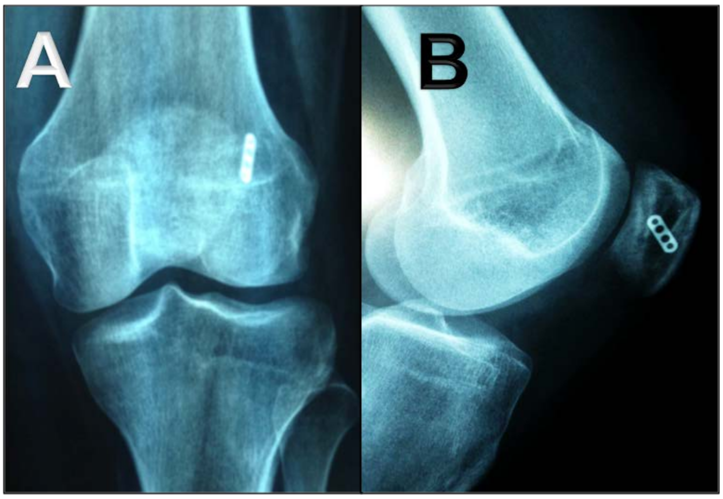


Table 2 – Post Operative Protocol

Timeline	Intervention
1st Day	No Brace/ Knee Immobilizer Used
	Quadriceps Sets, Calf raises initiated
	Mobilize weight bearing as tolerated with two crutches
1st Week	Passive knee range of motion initiated
	Continue Quadriceps Sets, Calf raises advanced
2nd Week	Progress to single crutch as tolerated
	Continue Quadriceps Sets, Calf raises
	Continue knee range of motion
3rd - 6th Week	Full knee range of motion
	Stationary bike with minimal resistance and then progress as tolerated
	Closed-chain double-leg strengthening exercises as tolerated
6th - 12th Week	Start running when capable
	May progress to closed-chain single-leg strengthening as tolerated
	May begin functional exercises as tolerated
12th - 16th Week	Gradual return to sport

2.5 Statistical Analysis

The frequency of clinical outcome events were summarised using percentages. Functional outcomes were summarised by calculating the group mean and standard deviation for baseline and follow-up measurements. The differences between follow-up and baseline values for each knee were calculated in measurement units and the difference in patella height was calculated as a percentage of the baseline value. A 2-tailed paired t test was used to test for a statistical difference in baseline versus follow-up measures. A p-value <0.05 was considered statistically significant. Analyses were conducted using SPSS statistical software.

3. Results

3.1 Participants

Our study reviewed 29 individuals (31 knees) with a median follow-up of 43 months (24 – 68 months). Patient characteristics and baseline clinical findings are summarised in Table 3. The mean patient age at the time of the procedure was 25 (9 – 44) years. The average duration of instability before the procedure was 1 (0.25 – 10) year. More than 50 % of the study population had an element of generalized ligamentous laxity. 52 % of the individuals had Grade IV Instability (Table 4). The age of onset of dislocation and the amount of trauma required to cause dislocation was found to be consistently lower in this subset of individuals (Table 4). Dysplastic changes were evident on x-ray and MRI examinations in more than half the study population. There was no evidence of patella-femoral arthritis in any of the individuals.

Table 3 – Patient Characteristics, Baseline Clinical Findings, & Surgical Details

Characteristic	N (%)	Mean (SD)
Patient Characteristics, 29 patients		
Gender male	11 (38)	-
female	18 (62)	-
Age (years)	-	25 (9)
Side left	16 (55)	-
right	15 (52)	-
bilateral	2 (7)	-
Baseline Clinical and Imaging Findings, 31 knees		
Maltracking	31 (100)	-
Apprehension	29 (94)	-

Ligamentous Laxity	17 (55)	-
Wynn Davies Scale		3 (1)
Duration of Symptoms (Months)	-	13 (14)
Surgical Technique, 31 knees		
Procedure		-
MPFL	29 (94)	
MPFL + Tibial Tubercle Osteotomy	2 (6)	-
Ligament		
LARS	5 (16)	
Merselene Tape	17 (55)	
Neoligament	9 (29)	-

Abbreviations: SD = Standard Deviation ; LARS = Ligament Augment Reconstruction System ; MPFL = Medial Patello-Femoral Ligament

Table 4 Baseline Classification of Patellar Instability, N=31 knees

Instability Grade	Joint Laxity	Insall-Salvati Index > 1.3	n (%)	Age at Onset, years Mean (range)	Bilateral Dislocations n	Moderate Trauma[1] n (%)
I	-	-	7 (23)	26 (18 - 44)	0	6 (86)
II	+	-	1 (3)	11 (7 - 16)	0	0 (0)
III	-	+	7 (23)	25 (15 - 42)	0	3 (43)
IV	+	+	16 (52)	14 (8 - 25)	2	6 (38)

1. Moderate: Direct force against the patella or indirect forces associated with athletics

Surgical details are summarised in Table 3. The LARS Ligament was used in the first 5 knees. We shifted to use of Mersilene Tape (17 knees) and subsequently to use AchilloCord^{PLUS} Ligament. A tibial tubercle osteotomy to medialize the tibial tuberosity was performed in 2 cases (TT-TG distance > 15 mm with persistent maltracking after MPFL reconstruction).

3.2 Clinical Outcomes

Using the Crosby and Insall grading [22], 21 knees (68%) were graded as excellent, 9 knees (29%) were good, 1 knee (3%) as fair to poor and none as worse at the last follow-up assessment. At 1 week, all patients had started knee bending and could achieve 70 – 90 ° of flexion. 30 knees had full range of motion of more than 150 ° while 1 knee had a slight loss of flexion 20 ° at their last follow up. Passive patellar hypermobility with the knee extended and flexed at 20 ° and mal-tracking was present in all knees pre-operatively. At follow-up, 2 knees were judged to have mild hypermobility and none had severe hypermobility or mal-tracking. The apprehension test was positive in 96 % of the knees pre-operatively (Table 3) and was found positive at the follow-up only in 1 knee (2%). Generalized ligamentous laxity was seen in 15 patients (17 knees – 55 %) with a mean score of 3 (3 – 5) (Table 3). In this subset 12 knees were graded as excellent, 4 knees as good and 1 knee as fair to poor according to the grading by Crosby and Insall.

Graft fixation was stable in all patients at 12-month follow up. One patient had a re-dislocation 9 months after surgery. Four patients had prominence of the ligament over the medial femoral condyle. Three patients presented with anterior knee pain at their 24-month follow up. No other major complications were reported. The sulcus angle was 137 (range 128 – 159) ° pre-operatively. The mean patellar height was 1.5 (s.d. 0.4) pre-operatively, and showed a statistically significant improvement to 1.4 (s.d. 0.3) at follow-up ($p < 0.001$) (Table 5).

3.3 Functional Outcomes

All patients improved at their 24 month follow-up for the Lysholm knee score (score mean improvement 67, s.d. 10, range 18 – 87, p-value < 0.001, paired t test) (Table 5). These outcomes remained consistent at their final follow up.

Table 5 – Functional outcomes at 24 months

	Baseline	Follow Up	Mean difference between baseline and follow up	
	Mean (SD)	Mean (SD)		P - Value
Lysholm Knee Score	20 (19)	87 (9)	67 (10)	< 0.001
Insall-Salvati Index	1.5 (0.4)	1.4 (0.3)	0.1 (0.1)	< 0.001

SD=standard deviation

4. Discussion

Over the last two decades, the MPFL has been accepted as the primary restraint amongst the structures stabilizing the patella from cadaveric and biomechanical studies [24, 26]. Our study makes an important contribution to the evidence about the safety and effectiveness of a minimally invasive technique to reconstruct the MPFL using an artificial ligament. We report on the surgical and rehabilitation protocol and provide descriptive information about the clinical benefits and safety in a broad population of patients with all grades of patellar instability, including those with ligamentous laxity and patella alta. This is the first published report of an MPFL reconstruction procedure we are aware of that does not use a knee immobilizer post operatively.

The ideal characteristics directing graft choice for ligament reconstruction have been previously described as: similarity to the natural ligament structure and biomechanics, allowing secure fixation, speedy integration, and reduced donor site morbidity [27]. Artificial ligaments have been widely used in cruciate ligament surgery from the 1980's secondary to their easy availability and reduced donor site morbidity [28]. Our findings contribute to the growing body of evidence that their use for MPFL reconstruction substantially reduces the risk of patella re-dislocation. Overall, we observed excellent to good clinical outcomes (Crosby and Insall grading system), statistically significant improvement in functional (Lysholm score) and radiological (Insall – Salvati Index) outcomes in 98 % of our study population.

Our positive findings are consistent with the favourable results reported for artificial ligaments in extra-articular ligament reconstruction (Medial Collateral Ligament, Postero-lateral Corner and MPFL) by others [5, 17, 29-31]. Most recently, a three year follow-up study of 18 knees by Berutto et al (2014) presenting with objective patellofemoral instability that underwent a MPFL reconstruction with a bioactive artificial ligament, reported an overall satisfaction rate (88.8%), improvement in Kujala score (57 - 84.3) and IKDC scores (42.4 - 70.1), with one patient requiring revision surgery [30]. Studies of MPFL reconstruction using allografts like the gracilis or the semitendinosis have reported similar functional outcomes. However, one recent study has reported a higher incidence of revisions at 6-49 months follow-up (n=8 of 87 patients, 90 reconstructions) due to stiffness or re-dislocation in addition to donor site morbidity [32].

The operative technique in our study involved arthroscopy and minimal incisions, thereby not violating the extensor mechanism compared to standard open surgical techniques that have been previously assessed, which involve extensive surgery [8].

The potential advantages for patients include reduced postoperative swelling, reduced pain, reduced risk of complications, and improved recovery times. Importantly in this study, we demonstrate that our approach also allowed post-operative rehabilitation without a knee immobilizer. Various techniques including patellar drill holes, sutures, suture anchors and interference screws at the femoral condyle have been used for graft fixation during MPFL reconstruction. Mountney et al replicated MPFL reconstructions techniques using sutures +/- bone anchors, blind tunnel tendon graft and a through tunnel tendon graft in a cadaveric study and suggested that the latter technique provided comparable strength to the native ligament (195 N) [33]. A recent systematic review on the safety of MPFL reconstruction techniques (25 studies) reported 164 complications in 629 knees [34]. The findings suggest a trend of higher overall complications with tunnel techniques (29.8%, including redislocation 3.3 %, patellar fractures 2.4 %) compared to suture techniques (21.6%, 4.8 % re-dislocation, patellar fracture 0 %) [34]. Anatomical replication of the native MPFL in our study using an artificial ligament with no complications associated with the tunnel technique suggests good safety.

Safety concerns for artificial ligaments include rupture, synovitis, chronic effusions, cross-infections, and osteolysis [35]. A case series of 126 patients using polyethylene ligaments with a long term follow up of 19 years showed re-ruptures (27.5%) and osteoarthritis (100 %) as complications in addition to functional impairment (29.4 %) [35]. Shah et al in their systematic review concluded that MPFL reconstruction is a successful procedure, however, the complication rate of 26.1% associated with this procedure was not inconsequential [34]. At a median follow-up of over 2 years, we observed no serious adverse events in any individuals receiving this technique at our centre and graft fixation was stable for all but one individual. The re-dislocation occurred in one knee with grade IV instability secondary to a significant fall 9 months after surgery. The MPFL was revised with a tibial tuberosity osteotomy within a week after the fall and the graft was intact intra-operatively. This knee was graded as fair to poor at follow up as per the Insall & Crosby Grading System [22]. The other adverse events included prominence of the ligament over the medial condyle and anterior knee pain in 4 and 3 knees respectively. The prominence was noted in the first few knees (n = 2), attributed to the bulkiness of the LARS, hence we discontinued its use but managed these knees conservatively. Mersiline tape was used as an alternative to LARS. In 17 patients, 2 suffered from a similar complication as seen with the LARS. This was attributed to the rough texture of the tape. Therefore we shifted to AchilloCord^{PLUS} Ligament, which is a densely woven polymer and smooth in texture. An MRI was repeated for patients with anterior knee pain and they were subsequently treated with another arthroscopy and chondroplasty (n = 3). Together with data reported on artificial ligament use by Nomura et al (n = 27) and Berruto et al (n = 18), there are now more than 75 cases of isolated MPFL reconstruction for patella-femoral instability reported [29, 30]. The complication rate including the re-dislocation rate has been extremely low (n = 1), with low persistence of apprehension (n = 4) in our study. Altogether, we believe our favourable results and acceptable incidence of minor complications can be attributed to careful patient selection, the minimally invasive technique, anatomical placement of the femoral insertion, accurate tunnel placement, absence of morbidity associated with hamstring or quadriceps allografts and a strong post operative rehabilitation regime.

An important feature of our study is that the majority of our study population had ligamentous laxity with 55 % (n = 17) of the individuals classified as grade IV instability (Table 4). Similar to the findings of Runow et al (1983) [2], we observed that this subgroup appeared to have a lower age of onset and a history of minimal trauma. In the past, severe instability has been treated with a combination of soft tissue and bony realignment procedures [3, 6, 36]. There has been insufficient evidence to date to demonstrate the role of only MPFL reconstruction with or without lateral release in this subpopulation. A subgroup analysis conducted in patients with severe instability in our study showed improvement in clinical and functional outcomes for all 17 knees (16 (99%) - Excellent & Good, and mean increase in Lysholm score by 68 points). These favourable results indicate the procedure is suitable for individuals with ligamentous laxity and patella alta.

As a case series, the main weakness of our study is that it does not allow a direct comparison with conservative treatment or other reconstruction techniques to estimate the magnitude of the clinical benefits using our approach. Nevertheless, based on historical comparison with the outcomes of conservative treatment reported in the literature, in particular for re-dislocation rates, we believe the highly favourable outcomes we observed indicate true benefits for the use of a minimally invasive technique and artificial MPFL graft, and are unlikely to be due to chance or the favourable selection of patients alone.

Another limitation of our study is the lack of long-term follow-up. Given the good outcomes, achieving on going follow-up of this patient group will be challenging, but essential to report long-term results. There is a need for other centres to report their results to build the evidence base on long-term benefits and harms, and to define which patient groups with acute patellar dislocation are most likely to benefit versus conservative management. If other centres report similar findings to the present study and clinical equipoise is lost, it may not be feasible to recruit patients to a rigorous randomised controlled trial to compare this approach versus conservative treatment. However, trials comparing this procedure with alternative allograft techniques are warranted.

5. Conclusion

These mid-term results demonstrate the clinical and functional benefits of this minimally invasive surgical technique using an artificial ligament, and suggest these benefits are achieved with a low risk of complications, with a minimal damage to the extensor mechanism, including in those with severe instability.

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Legends

Tables

1. Inclusion / Exclusion Criteria
2. Post-operative Protocol
3. Characteristics, Clinical Findings, & Surgical Details
4. Classification of Patellar Instability
5. Results

Figures

1 – Patellar Tunnel

a. Clinical Image b. X-ray Image

2 – Graft Construct

a. Artificial Ligament, b. Endobutton, c. Interference Screw, d. Through Tunnel Technique

3 – Final Graft Position

4 – Plain X-rays

a. Antero-posterior b. Lateral