Comparison of the success of medial patellofemoral ligament reconstruction techniques

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Declaration

I **Peter Richard Almeida** declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Orthopaedic Surgery at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

……

(Signature of candidate)

14th day of NOVEMBER 2023 in Johannesburg

Dedication

I dedicate this to my wife, Natalie Ruivo Almeida, and my family who have given me tremendous support allowing me to achieve my goals.

Presentations and publications arising from the research project

Presented “Comparison of the success of medial patellofemoral ligament reconstruction techniques”at the South African Orthopaedic Association in Cape Town 5 September 2022 and nominated as top 5 registrar paper for the GT Du Toit award – Awarded 3rd place

Abstract

Introduction

Recurrent lateral patella instability is multifactorial, with the current emphasis of treatment being to restore the medial stabilising structures to prevent further dislocations and complications. Many treatment options have been documented and Medial Patella Femoral Ligament (MPFL) reconstruction has become the most common surgical method, yet there is no gold standard technique reported for MPFL reconstruction. The aim of this study was to compare the success of different MPFL reconstruction techniques especially double bundle technique (DBT) *versus* single bundle technique (SBT).

Methods

A retrospective review of the records of patients who had MPFL reconstructions performed over a 10-year period at a single orthopaedic practice was conducted. Patient demographic details, including Body Mass Index (BMI) and the surgical technique used, including DBT or SBT, and graft choice were recorded. Outcome measures included re-dislocation rate, Kujala knee questionnaire, Tegner activity scale and visual analogue scale (VAS) assessing satisfaction.

Results

One hundred and thirty-three patients underwent MPFL reconstruction, 17 patients were excluded. Thirty-one patients were lost to follow up. A total of 85 (73.28%) patients were assessed. Mean age was 23.9 years and 63.53% (n = 54) were female. The average follow up was 80.6 months, with 3.5% (n = 3) patients that re-dislocated requiring revision surgery. The mean Kujala knee score was 85, the mean Tegner activity scale was 5.6 and the mean VAS satisfaction score was 9. DBT reconstructions accounted for 45.9% (n = 39) of procedures, while 54.1% (n = 46) of patients underwent SBT reconstruction. Of the SBT group 19.57% (n = 9) utilised allograft. No statistical significance between dislocation rate (p = 0.810), Tegner activity score (p = 0.155), Kujala knee score (p = 0.265) or patient VAS satisfaction scores (p = 0.989) between the DBT and SBT groups was found. No significant difference was found in the outcomes between allograft and autograft. Sixty-nine percent of patients completed

rehabilitation, with significantly higher Kujala knee scores noted in those patients (86.8 ± 10.586) compared to than those who did not complete rehabilitation (81.04 ± 14.05) (p = 0.040).

Conclusion

The use of either SBT or DBT in MPFL reconstruction, as well as the use of allograft or autograft, resulted in similar favourable outcomes. This follows the trend reported in previous literature. Other factors such as rehabilitation and articular damage noted at the time of surgery may influence outcomes more. Higher-powered prospective studies are required to better determine which techniques may be superior.

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Nomenclature

CT	Computed Tomography
DBT	Double bundle technique
ISB	Inferior straight bundle
MPFL	Medial patellofemoral ligament
MRI	Magnetic resonance imaging
PFJ	Patellofemoral joint
PROM	Patient reported outcome measure
Q angle	Quadriceps angle
ROM	Range of motion
SBT	Single bundle technique
SOB	Superior oblique bundle
TT-TG distance	Tibia tubercle-Trochlea groove distance
VAS	Visual Analogue Scale
VMO	Vastus medialis obliquus

CHAPTER 1

1. Introduction and Literature review

Patellar instability is used to describe a spectrum of disorders related to the patellofemoral joint (PFJ) that includes general symptomatic instability, patella subluxation as well as patella dislocation (1). Dislocation of the patella is an injury that occurs more commonly in the young active population with approximately 55 – 70% of dislocations occurring during sports participation (2,3). Patella dislocations occur most commonly in the lateral direction resulting in damage to the medial soft tissue structures supporting the PFJ (2,4). Although the loss of the integrity of the medial structures may result in recurrent dislocations, it is important to note that lateral patella instability may be multifactorial (5,6).

Restoring the integrity of the medial structures is the core philosophy in preventing recurrent dislocations, and failure to address the instability can lead to further complications of the PFJ (7). There have been many surgical techniques described to address patellar instability, but over the last two decades, Medial Patellofemoral Ligament (MPFL) reconstruction has become the most common surgical treatment used for recurrent lateral patella instability (6,8,9). The knowledge of the anatomy and biomechanics of the PFJ, together with the pathophysiology of patellar instability, have expanded leading to an evolution in techniques used in MPFL reconstruction (7,10). With the many techniques described, there has been no agreement concerning the gold standard and the choice of the optimal MPFL reconstruction technique still needs to be determined (7).

1.1 Epidemiology

Patella dislocations are estimated at 6 – 43 per 100 000, with a peak incidence reported at 15 years of age (2,3,11,12). It has been reported that 2 – 3% of all knee injuries include patella dislocations, with a higher incidence in female patients (1,3,13). With more than two patella dislocations the recurrence of patella instability has been recorded at greater than 50% (12,14).

1.2 MPFL anatomy and function

Both the osseous structures and the surrounding soft tissues play a crucial role in the stability of the patella during motion of the knee (5,8,15). The medial structures providing stability and controlling the movement of the patella include the MPFL, the medial patella retinaculum, medial patellomeniscal ligament and the vastus medialis obliquus (VMO) (5). The MPFL acts as the primary static restraint to lateral patella movement, providing a range of 53% to 67% of all soft tissue restraint (7,9,10,16,17). The MPFL is the major restraint to lateral subluxation in the knee range of motion (ROM) of 0 – 30º (9,15). During lateral patella dislocations, there is injury to the medial soft tissues, and in 94 – 100% of these cases the MPFL is injured (2,4,7,16,17).

The MPFL has been described as a thin, triangular shaped, fibrous tissue connecting the medial border of the patella to the medial femoral condyle (see Figure 1.1) (4,5,9,14,15). The apex of the described triangle originates from the posterior part of the medial epicondyle and distal to the adductor tubercle on the femur, and fans out to the patella *via* two functional bands of fibres forming the superior and inferior sides of the triangle (5,9,15). These two functional bands have been described as the superior oblique bundle (SOB) and inferior straight bundle (ISB), although they are not separate structures as both form part of the intact MPFL (5,9). The base of the triangle is formed by the broad insertion onto the superior half of the medial border of the patella beneath the VMO and some studies describe attachments of the SOB to the quadriceps tendon and VMO (5,9,10).

The MPFL acts as the primary stabiliser of the patella during the initial 30 degrees of knee flexion guiding the patella into the trochlear groove, thereafter it slackens as knee flexion continues (the MPFL anisometry) with the trochlear groove providing most of the stability (5,9,18,19). The SOB provides restraint in early knee flexion and due to having fibres attached to VMO, an element of dynamic stability is provided (5,20). The ISB provides static restraint to lateral patella translation with maximum restraint provided in mid-flexion (5,20). The anisometry of the native MPFL is important to note and understand during MPFL reconstruction as it is the femoral attachment of the graft that has a major contribution to this anisometry and malposition of this femoral attachment has been reported as a risk factor for poor outcomes (see Figure 1.2) (2,14,15,18,19,21).

Multiple bony abnormalities contribute to patella instability including patella alta, trochlea dysplasia and lateralisation of the tibial tubercle noted by an increase tibial tubercle-trochlea groove (TT-TG) distance (1,22). Patella alta results in the patella engaging the trochlea groove at a later stage during flexion of the knee resulting in increased strain applied to the medial stabilising structures (1,22). Trochlea dysplasia results in less bony support by the femur (1,22). An increased Quadriceps angle (Q angle) contributes to patella instability and may arise from a lateralised tibial tubercle, as well as external tibial torsion, genu valgum and femoral anteversion (22,23). Identifying and investigating these pathoanatomical features appropriately is important in guiding the correct management when addressing lateral patella instability.

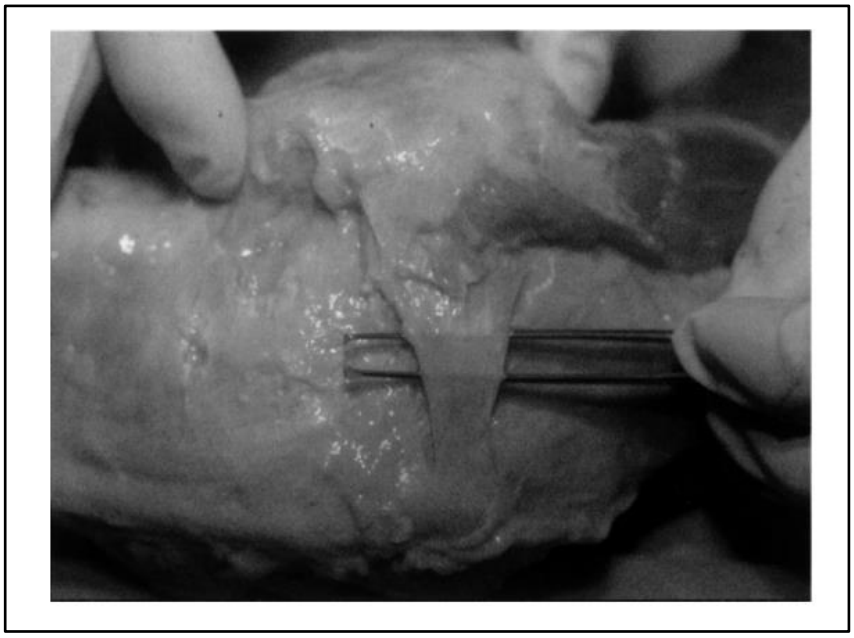

Figure 1.1: Image depicting the dissection of the medial aspect of a right knee showing the MPFL, connecting the medial edge of the patella to the distal femur. Picture from Amis et al. (2003) (15)

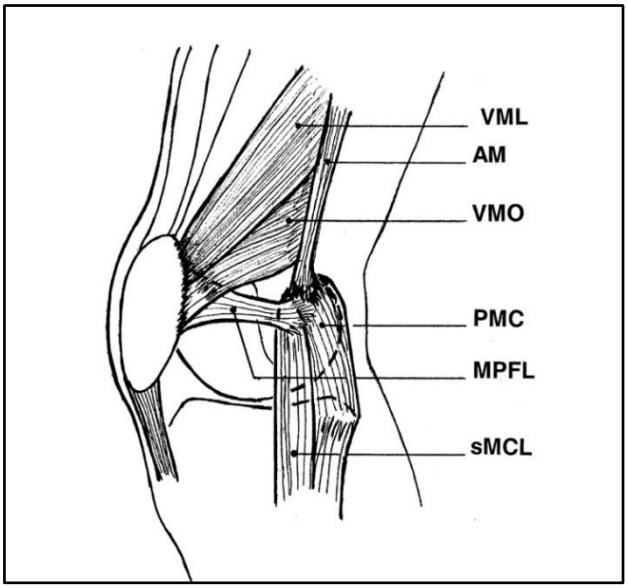

Figure 1.2: Schematic diagram of the medial aspect of a right knee showing the MPFL, and the relationship to other structures. VML – Vastus medialis longus, AM – Adductor magnus, VMO – vastus medialis obliquus, PMC – posteromedial capsule, MPFL – medial patellofemoral ligament, sMCL – superficial medial collateral ligament. Picture from Amis et al. (2003) (15)

1.3 Clinical presentation and investigations in lateral patella instability

Recurrent patella instability may result in diffuse knee pain, tenderness and swelling of the knee (2,24). Examination of the knee may reveal a positive patella apprehension test and a 'J sign' may be present (24,25). The apprehension test involves attempting to laterally translate the patella while the knee is in extension and observing any apprehension expressed by the patient (23). The 'J-sign" assesses patella tracking and is observed when watching the patient flex and extend their knee while sitting over the end of the examination table (23). With a positive "J sign" the patella moves markedly lateral in extension and an obvious medial relocation of the patellar occurs in flexion. The track the patella takes is the shape of a "J" (23). Due to the multifactorial nature of patella instability, the examination should not be isolated to the knee but include an evaluation of the gait pattern, and examination of the entire limb focusing on overall limb alignment including the soft tissue structures as well as the osseous structures (25). Genu varus/valgus orientation, trochlear dysplasia, rotational deformities of tibia and femur, patella height, long patella tendon, lateral insertion of the patella tendon, Q

angle, ligamentous hyperlaxity, muscular imbalance, forefoot pronation and joint degeneration should all be investigated appropriately and addressed where necessary (8,9,19,25). Radiographs of the knee, long standing radiographs, CT (computed tomography) scan as well as Magnetic resonance imaging (MRI) may be utilised in the assessment of these pathologies (9). Lateral radiographs are used to identify patella alta with multiple indexes having been described to assess patella height such as the Caton-Deschamps index (9). Trochlear dysplasia and may be assessed on lateral radiographs and classified according to the Dejour classification (9). In addition, MRI may be used to measure lateral trochlear inclination while simultaneously assessing the quality of the articular cartilage (9). CT scan is useful in assessment of rotational abnormalities and measuring the TT-TG distance (9).

1.4 Management of lateral patellar instability

Non-operative management after an acute patella dislocation has been reported to result in a 15% to 80% chance of re-dislocation (7,9,11). Although there is a chance of re-dislocation, non-operative treatment should be attempted initially if appropriate, and if this fails, operative management can be considered (11).

Traditionally surgical procedures can be divided into proximal (repair of MPFL, reconstruction of MPFL, medial imbrication, lateral retinacular release, trochleoplasty and femur realignment osteotomies) and distal (Tibia osteotomy, tibial tubercle osteotomy) realignment surgical procedures to manage recurrent patella instability (1,26–28). Recent evidence shows that MPFL reconstruction has been associated with favourable clinical outcomes and has become an established and common choice of surgical management (2,6–8). Reconstruction differs from repair in that the incompetent MPFL is reinforced with a strong graft as opposed to stitching the damaged ends of a stretched graft together. Management begins with clinical and radiological assessment of the previously mentioned pathoanatomical risk factors (29). It has been highlighted that the presence of a single pathoanatomical risk factor may not be as significant as when there are multiple risk factors present that would need better risk stratification to adjust the correct management approach (21). There still is some controversy whether the reconstruction of the MPFL can be done independently or should be done in conjunction with other bone or soft tissue procedures addressing the concomitant

pathoanatomic risk factors, especially when considering the increased surgical time, morbidity and associated complications related to these procedures (9,19,21,26).

1.5 MPFL reconstruction techniques

Indications for MPFL reconstruction include recurrent dislocations and persistent instability that have failed conservative management, or the presence of intra-articular loose bodies or unstable osteochondral defects necessitating surgical intervention (11,16). The development in the understanding of the structure of the MPFL and kinematics of the patella has led to the evolution of numerous techniques used in reconstruction of the MPFL. The reconstruction techniques described differ in the various choices of grafts, the number of graft bundles and the graft-osseous fixations used in the MPFL reconstruction (8,10,16). Favourable clinical outcomes have been reported with isolated MPFL reconstruction, even in the presence of abnormal bony pathology indicating that bony pathology does not always require surgical intervention (2,8,11). Some studies have shown that severe bony pathology, such as trochlea dysplasia and increased TT-TG distance, may need to be addressed with MPFL reconstruction to prevent failure of the reconstructed ligament and recurrent instability (26,27). As previously mentioned it must be noted that addressing these concomitant pathologies may be associated with increased associated morbidities (11,19,26). These morbidities include but are not limited to loss of correction, stiffness due to periarticular scar formation, stress fractures, non-union of osteotomy site and irritation due to prominent hardware used in fixation (27,28).

MPFL reconstruction may be performed using a graft in a single bundle technique (SBT) or double bundle technique (DBT) configuration (see Figure 1.3). The SBT was initially described but the DBT has become more popular (5,30) . Biomechanical studies comparing SBT and DBT have found that both reconstruction techniques are able to restore stability to the patella, with the ultimate load of 171 ± 51 N and 213 ± 90 N recorded respectively for SBT and DBT (31) . The DBT is suggested to simulate the native anatomy of the MPFL described previously, replicating the SOB and ISB and increasing resistance to lateral patella movement, while restoring the biomechanics of the PFJ with the correct anisometry of the MPFL (14,17,30). The 2 reconstructed bundles inserted into the patella with the DBT distribute the physiological load better than the SBT, and has been reported to provide more resistance to lateral movement within the first 15^{o} of knee flexion (31,32). Kang et al. (2019) published a systematic review

reporting that SBT and DBT resulted in similar outcomes regarding knee function, post-operative instability and complications (30). Persistent anterior knee pain (5.1 %) was more common with SBT and patellar fracture (1.2 %) and knee stiffness (3.5 %) was more common with DBT (30). Wang et al. (2013) found that over a longer period of follow up with the SBT, the incidence of patella instability increased when compared to the DBT (17). Bouras et al. (2019) reported a mean post-operative Kujala score of 92 for the DBT using the gracilis tendon (8). Astur et al. (2015) compared DBT with suture anchor fixation, to a SBT with a transpatella-drilled tunnel and an endobutton fixation and found that they had similar outcomes at two years and five years follow up (10).

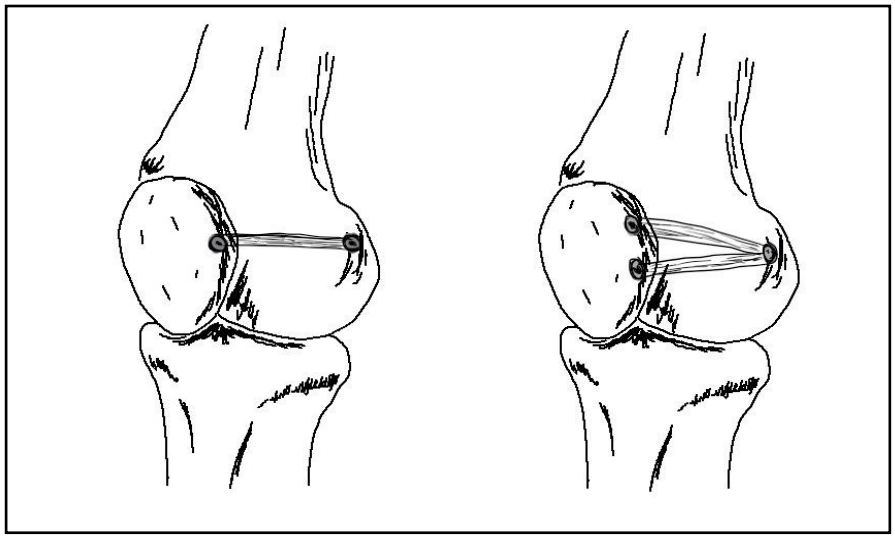

Figure 1.3: Schematic diagram describing MPFL reconstruction with graft in SBT configuration (left) and DBT configuration (right)

MPFL reconstruction has been described using autologous graft from harvesting the gracilis, semitendinosus, adductor magnus or quadriceps tendons, or may utilise allografts or synthetic grafts with numerous methods of fixation (8,16,24,33). The native MPFL is able to withstand a force of 208 (± 90) N (15,24,34). Gracilis, semitendinosus and patella tendon grafts have all been shown to withstand forces significantly greater than the native MPFL, although tensile strength is dependent on the diameter of graft as noted in Table 1.1 (24,35,36). McNeilan et al. (2018) reported in a systematic review that autografts of gracilis, semitendinosus and patella tendon resulted in < 2% rate of recurrent instability, but there are risks of neurovascular injury, haematoma, infection, and pain to the donor site with harvesting of the autologous grafts as well as the risk of autograft stretching over time (33).

Table 1.1: The approximate tensile strength of graft tissue compared to the native MPFL

Tendon / Ligament	**Mean tensile strength**
MPFL	208 N (15,24,34)
Bone Patella Tendon Bone (14 mm)	2900 N (35)
Semitendinosus tendon (3.7 mm)	1060 N (35)
Gracilis tendon (3.1 mm)	837 N (35)

The use of allograft has quicker surgical times and negates the risk of complications associated with harvesting of autograft, and failure rates have been reported as similar between allograft and autograft reconstructions (37–39). However, the use of autograft had reportedly better improvements in Kujala knee scores compared to the use of allograft according to a systematic review by Weinberger et al. (2017) (37). The availability of safe allograft and whether it is fresh-frozen or sterilised with radiation needs to be considered. The risk of infection, tissue reaction/rejection, capacity to heal and maintenance of graft tension needs to be considered when using fresh-frozen tendon allografts (40). With irradiated tendon allografts, the type and dosage of radiation used on the specimens has shown to affect the biomechanical properties of the allografts, although the majority of studies are directed at tendon allografts used in anterior cruciate ligament reconstructions, which need higher loads to failure than MPFL reconstruction (40).

Synthetic grafts such as Leeds-Keio and Fibre Tape are effective and safe options used in MPFL reconstruction and lack the possible risk factors associated with autologous graft harvesting, however it should be noted that they are more rigid than autograft or allograft (33). The correct anatomical location for fixation of the graft on the medial femur is critical in restoring the PFJ biomechanics required to avoid excessive strain on the graft and to achieve good clinical outcomes (2,14,18,21). Accurate insertion of graft into the femoral site affects graft anisometry through knee ROM, as the required change in tension and length of the reconstructed MPFL during knee ROM depends largely on the position of the femoral graft insertion site (15,18,19). For the correct anisometry, the suggested tension of the MPFL should be isometric from 0^o - 30^o of knee flexion (11,19). In order to achieve this correct anisometry, the graft fixation and tensioning should be performed in 30^o – 40^o of knee flexion (1,10,17).

This has been suggested to prevent over tensioning of the graft because in extension the patella is not centred in the trochlea groove as it is in 30^{o} of knee flexion (18). Schottle's point has been described as the optimum insertion point for the femoral tunnel, and >10 mm away from this point has been reported as a risk factor for patella re-dislocation and worse patient reported outcomes (21). Palpation of anatomical landmarks intra-operatively, the adductor tubercle and medial epicondyle, may be used to locate the correct insertion point on the femur but intra-operative fluoroscopy may be utilised to increase the accuracy of the correct femoral insertion point (11,18,41). In conjunction with intra-operative fluoroscopy and palpation of anatomical landmarks, the correct femoral insertion point may be checked by attaching a suture from the proposed patella insertion position to the femoral insertion point and assessing the tension through knee ROM (18,42).

There are several fixation techniques used for osseous attachment of the graft on the femur and the patella (33). Femur graft fixation options include a suture anchor, an interference screw, a staple or a transosseous tunnel with a fixed loop button (39). The patella fixation options include a single transosseous tunnel, a double transosseous tunnel, an interference screw, a suture anchor, a transosseous suture fixation or the use of a fixed loop button (43). Some of the factors to consider with patella graft fixation include but are not limited to fracturing the patella, failure of the fixation and tissue irritation and pain at the graft insertion site (2,6,9). Despite the reported complications, the fixation techniques using patellar bone tunnel, suture anchor and suture techniques have shown to produce similar outcomes for MPFL reconstruction (6).

1.6 Complications of MPFL reconstruction

Post-operative complications include iatrogenic medial instability, ongoing lateral instability due to too little graft tension, loss of flexion due to misplaced femoral attachment points, re-dislocations, graft failure, patellar fracture, arthrofibrosis, PFJ degeneration, residual pain and wound complications (9). Specific complications may be dependent on the technique used, such as harvesting of autologous graft (33). A meta-analysis by Schneider et al. (2016) reported a pooled post-operative recurrent instability of 1.2%, a positive apprehension sign risk of 3.6% and a reoperation risk of 3.1% (2). Risk factors have been suggested to affect the outcomes of MPFL reconstruction, include older than 30 years of age, female sex, obesity and high-grade chondral injury of the PFJ, although there is no universal agreement, regarding all these factors

(7–9). Further information regarding risk factors would be beneficial in preventing adverse outcomes.

1.7 Outcome measures used in MPFL reconstruction

Within the last decade there have been two patient reported outcome measures (PROM) designed specifically for patellar instability which include the Banff Patella Instability Instrument developed in 2013, and the Norwich Patellar Instability score developed in 2012 (44,45). PROMs used to assess pain of the PFJ such as the Kujala knee score, Lysholm score, Fulkerson score and Tegner scales have also been used in literature regarding patellar instability (2,25,44). The Kujala knee score and Tegner scales are PROMs commonly used in the assessment of patellar instability have reported good test-retest reliability (25,45,46). The Kujala knee score, developed in 1993, is designed as a questionnaire and is one of the most frequently used PROMs in studies regarding MPFL reconstruction and PFJ disorders (2,45–47). It has been validated in several languages (16,48). The scale is used to assess various activities of daily living, with 13 questions and the totals are scored on a scale of 0-100, and can be self-administered (2,25,47). Walsh et al. (2022) reported the minimal clinical significant difference of PROMS used in MPFL reconstruction including the Kujala knee score and found that older age, higher pre-operative scores were less likely to report improvement, and male patients were more likely to report improvement (49). The Tegner activity level scale can be self-administered and is scored from 0 – 10 describing the level of activity and sporting participation of a subject and has been validated in cohorts assessing patellar instability (2,25,50). Qiao et al. (2023) reported the minimal clinical important difference for the Kujala knee score and Tegner activity level was 9.1 and 0.9, respectively (51).

There have been no tools specifically designed to measure patient satisfaction after MPFL reconstruction, as satisfaction is difficult to quantify. The satisfaction Visual Analogue Scale (VAS) has been successfully used to assess and quantify patient satisfaction after total hip and knee arthroplasty (52). A horizontal 100 mm line is used with ‘no satisfaction’ labelled at one end of the line and ‘complete’ satisfaction at the other end, with an explanation for the patient to make a mark on the line rating their level of satisfaction (52). Using the satisfaction VAS to assess patient satisfaction post MPFL repair and comparing those scores of different MPFL techniques would provide more insight into MPFL reconstruction technique choice.

1.8 Conclusion

Recurrent lateral patella instability is a common pathology affecting young active patients with knee injuries. Surgical reconstruction of the MPFL is the preferred technique to prevent further dislocations and subsequent damage to the PFJ. There is heterogenicity of both the studies and description of the techniques in the literature resulting in difficulty comparing the various components utilised in the reconstruction of the MPFL (6). There are few adequately powered studies available that compare the various technical aspects of the reconstruction, including graft type, graft fixation, and the number of graft bundles, with success of the procedure and PROMs. To date, no technique has yet been described as the gold standard. By conducting a retrospective review of patients having undergone MPFL reconstruction and comparing the outcomes of re-dislocation rate, PROMs and return to pre-operative level of activity to the specific technical choices used in the MPFL reconstructions, it is believed a better understanding regarding the best options of MPFL reconstruction will be obtained.

1.9 Study Aim and Objectives

1.9.1 Aim

To compare the success and outcomes of the surgical techniques used in MPFL reconstruction

1.9.2 Primary Objective

- To compare the success of DBT *versus* SBT in MPFL reconstruction with regards to the incidence of re-dislocations post-operatively.

1.9.3 Secondary Objectives

- To compare patient outcomes post-operatively of MPFL reconstruction with SBT *versus* DBT using the Kujala knee score and Tegner activity score and the VAS for patient satisfaction.
- To determine if the choice of graft in MPFL reconstruction affects the patients' outcomes.
- To determine if the choice of graft in MPFL reconstruction affects re-dislocation rate.
- To determine whether post-operative rehabilitation was completed after MPFL reconstruction.
- To determine whether post-operative rehabilitation affected patient's outcomes and re-dislocations rate
- To assess demographic factors that may predispose to an adverse outcome.

CHAPTER 2

2. METHODOLOGY

2.1 Research Questions

- Does the DBT in MPFL reconstruction result in less dislocations and better post-operative outcomes compared to SBT?
- Does the choice of the graft of MPFL reconstruction have an influence on patient outcomes?
- Do patient demographic differences influence the success of MPFL reconstruction surgery?
- Do patients undergoing MPFL reconstruction complete post-operative rehabilitation?

2.2 Research Design

This study was a retrospective descriptive review of a cohort of private practice patients who underwent MPFL reconstruction at The Linksfield Knee and Orthopaedic Sports Rehabilitation Centre, Netcare Linksfield Clinic and the Centre for Sports Medicine, Netcare Rosebank Clinic, between 01 January 2010 and 30 June 2020. The period was determined based on the availability of archived patient records over the 10-year period within the practice.

2.3 Data collection

All the files of patients that underwent MPFL reconstruction were reviewed. Patient demographic details were collected as well as the specific details of the surgical procedure including graft bundle type, graft type and graft fixation. Patients were followed up by a nursing sister at the practices with post-operative questionnaires. These post-operative questionaries include outcome measurement tools and were recorded in the files of the patients. These included information regarding any post-operative dislocations, the Kujala knee scores, the Tegner activity scores, VAS patient satisfaction scores, need for repeat surgeries and whether there was completion of a structured rehabilitation protocol. The questionaries were completed at different post-operative follow up periods. Due to the nature of private practice the follow up periods for completion of the questionnaires were not standardised.

2.3.1 Surgical technique

2.3.1.1 Surgical decision making process

Isolated MPFL reconstruction may be more prone to failure if the anatomical forces due to skeletal abnormalities are not corrected. Prior to surgery, the patients' relevant skeletal anatomy is assessed as is deemed appropriate by the surgeon. Tibial tubercle position is assessed clinically and radiologically using radiographs and CT scans. This is to assess patella alta and TT-TG positions. Based on the status of the physes, ligament laxity and measurements tibial tubercle osteotomies with distilisation, medialisation or both are performed by the surgeon. Proximal osteotomies of the femur and trochleoplasty are not performed in this unit (perhaps the outcome of this study may change this).

2.3.1.2 Single Bundle Technique

The MPFL reconstructions were performed by 3 senior knee surgeons in a standardised manner. Procedures were performed in supine position with tourniquet applied to thigh, and routine prophylactic antibiotics administered prior to inflation and skin incision. The leg was cleaned and draped in standard surgical manner. Examination of the knee under anaesthesia was performed to confirm diagnosis and assess the severity of patellar instability. Knee arthroscopy was performed via standard portals to assess intra-articualr pathology. 3cm incision over pes anserinus was made to harvest the gracilis tendon.

A 2 -3 cm incision was made along the medial border of the patella, with dissection down to the proximal 2/3 of the patella. A single J-shaped bone tunnel was drilled from the midpoint between the proximal and middle 1/3 of the medial part of the patella and exiting on the anterior cortex.

A 2-3 cm incision was made just posterior to the medial epicondyle and Schöttle point was identified using the landmarks of the medial epicondyle and the adductor tubercle. A bone tunnel was drilled into Schöttle point. The prepared graft was pulled through the patella tunnel, and tied onto itself while the other end was passed under the soft tissue and fascia and pulled through the femoral tunnel and secured with a biotenodesis interference screw. The graft is tensioned in 30^{o} of knee flexion. The patella position and stability is assessed through range of motion. Depending on the quantity of the harvested graft, interference screws may be used to secure the graft onto the patella. Abnormalities of the Q angle and TT-TG distance guided the need for tibial tubercle osteotomy.

2.3.1.3 Double Bundle Technique

The same patient set up and preparation described for SBT is used for DBT. The same incisions over the medial patella, medial femur and tibia are utilised as described in SBT. Two J shaped tunnels are drilled at least 1 cm apart in the proximal half of the medial border of the patella. The graft is passed through the tunnels and loped over and secured to itself, with the other graft end passed beneath the soft tissue and secured to the femur with a biotenodesis interference screw. The graft is tension in 30^{o} of knee flexion.

2.3.2 Measurement tools

- Kujala knee questionnaire (see Appendix C)
- Tegner activity scale (see Appendix D)
- Visual analogue scale (VAS) with satisfaction assessment question (see Appendix E)

The database used by the Orthopaedic surgery practice was used to identify all patients that underwent MPFL reconstruction over the specified period. From this database, the principal investigator reviewed patients' files. Patient demographic details were collected onto a patient data capture sheet (see Appendix A) and allocated a study number. Study number data sheets (see Appendix B) were used to capture details of the surgical procedures and the PROMs. Both sheets were kept separate to protect the identity of the study participants. Information from the study number sheets were captured onto a data spreadsheet (Microsoft Excel) for statistical analysis. This was a retrospective study and the sample size was dictated by the 10-year time period of archived files. All patient records that met the inclusion criteria were reviewed. The data from the patient data sheets (see Appendix A) and study number data sheets (see Appendix B) was captured manually by the principal investigator and entered into an Excel spreadsheet, from which the information was consolidated prior to statistical analysis by the biostatistician.

2.4 Ethics clearance

This study obtained ethical approval by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand prior to the commencement of the study (Ethics number: M200830) (see Appendix F). Permission to use patient records from the Orthopaedic surgery practices involved was obtained from the relevant Orthopaedic surgeons (see Appendix G).

Unique study numbers were allocated to the protect identities of patients and maintain confidentiality.

2.5 Selection Criteria

2.5.1 Inclusion criteria

- All patients with recurrent lateral patella dislocation that underwent surgical reconstruction of the MPFL at the same orthopaedic surgery practice by three senior orthopaedic surgeons from 01 January 2010 to 30 June 2020 were included.
- Minimal follow up was 1-year post MPFL reconstruction.

2.5.2 Exclusion criteria

- Patients with multiple ligament injuries, or fractures around the knee joint were excluded.
- Patients requiring multiple procedures that were not related to patella instability involving knee joint were excluded, as well as patients requiring revision surgery.

CHAPTER 3

3. RESULTS

IBM SPSS version 28 was used for the statistical analysis of the data. Descriptive statistics including frequencies and percentages were used to describe categorical variables. Continuous variables were described using medians and means. A Pearson's Chi-square test of independence was utilised on cross-tabulations to determine the association between the categorical variables of interest, and whether a significant relationship exists between two variables represented in the cross-tabulation. When conditions were not met, a Fisher's exact test was used. Spearman's correlation test was used to measure how the ordinal variables or rank orders were related, and Pearson's correlation coefficient was used as a measure of linear association. An unmatched paired student *t* test was used to compare continuous variables between the two groups within the study. A p-value < 0.05 was considered as statistically significant.

3.1.1 Summary of overall demographic profile, surgical groups and outcomes

Over the study period, a total of 133 knees underwent MPFL reconstruction and were included for review. Seventeen patients were excluded based on the exclusion criteria. Thirty-one patient files had no follow up data and therefore were not included in the analysis, as no outcome measures for comparison were available. A total of 85 knees that underwent MPFL reconstruction and had follow up data were included in the study for review, resulting in 73.28% follow up.

The summary of patient demographic and surgical procedure details can be found in Table 3.1. Of the 85 knees the majority were female patients, 63.53% (n = 54), and the mean age was 24 years (± 10.31). Forty-one (48.2%) were left knees and 44 (51.8%) were right knees. The mean BMI recorded was 25.1 kg/m^2 (± 5.95). The mean follow-up period was 80.6 months (± 34.86). Outcome measures for the entire cohort is summarised in Table 3.2. The mean Kujala knee score was 85/100 (± 11.97), pre-injury Tegner activity score was 6.1/10 (± 2.84), post-operative Tegner activity score was 5.6/10 (± 2.17) and VAS satisfaction score was 9/10 (± 1.318). The

reported re-dislocation rate was 15.29% (*n* = 13**),** and this was further broken down into one dislocation and more than one dislocation.

Table 3.1: Summary of patient demographics and procedure details

Variable	Categories	Frequency (%)	Median [IQR]	Mean (SD)
Patient demographics				
Gender	Male	31 (36.5)		
	Female	54 (63.5)		
Age (years)			20 [17; 29.5]	24.0 (±10.31)
BMI (kg/m^2)			24 [21, 28]	25.1 (±5.95)
Months of assessment post follow-up			85 [44; 110]	80.6 (±34.858)
Surgery details				
Side of surgery	Left	41 (48.2)		
	right	44 (51.8)		
Articular cartilage	No damage	15 (17.6)		
	Patella damage	50 (58.8)		
	Femur damage	3 (3.5)		
	Patella and femur damage	17 (20)		
Bundles	SBT	46 (54.1)		
	DBT	39 (45.9)		
Graft	Autograft	76 (89.4)		
	Allograft	9 (10.6)		
Associated procedure	None	35 (41.2)		
	Tibial Tuberosity medialised	12 (14.1)		
	Tibial Tuberosity distalised	13 (15.3)		
	Tibial Tuberosity distalised and medialised	11 (12.9)		
	Removal of loose bodies	7 (8.2)		
	Debridement of PFJ	5 (5.9)		
	Lateral release	3 (3.5)		
	Other	3 (3.5)		
Further surgery required post-op	No	78 (91.8)		
	Yes	7 (8.2)		

Table 3.2: Summary of outcomes of all patients

Outcomes	Categories	Frequency (%)	Median [IQR]	Mean (SD)
Post-operative rehabilitation completed	No	26 (30.6)		
	Yes	59 (69.4)		
Incidence of post-operative dislocations	Never	72 (84.7)		
	Once	4 (4.7)		
	More than once	9 (10.6)		
	Dislocation and requiring surgery	3 (3.5)		
Kujala knee score			88 [76.5; 93.5]	85 (±11.969)
Tegner activity score (pre-injury)			6 [4; 9]	6.1 (±2.838)
Tegner activity score (post-operative)			6 [4; 7]	5.6 (±2.17)
VAS Satisfaction score			10 [8; 10]	9 (±1.318)

3.1.2 Does the DBT in MPFL reconstruction result in less dislocations and better post-operative outcomes compared to SBT?

The DBT group (n = 39) compared to the SBT group (n = 46) had slightly more favourable Kujala knee scores and patient's VAS satisfaction scores (86.62 and 9.03) *versus* (83.7 and 9.02) respectively. These were not found to be statistically significant (p = 0.265 and p = 0.989) (Table 3.3). The DBT group had a lower re-dislocation rate compared to the SBT group (n = 5; 12.82% *versus* n = 8; 17.39%). This was not found to be statistically significant (p = 0.810).

Re-dislocation rate was further broken down into once and more than once with the summary of results shown in Table 3.4. From the SBT group, 10.9% (n = 5) of patients compared to 5.4% (n = 2) of patients from the DBT group required further surgery to the knee after MPFL reconstruction, but this difference was not found to be statistically significant (p = 0.810).

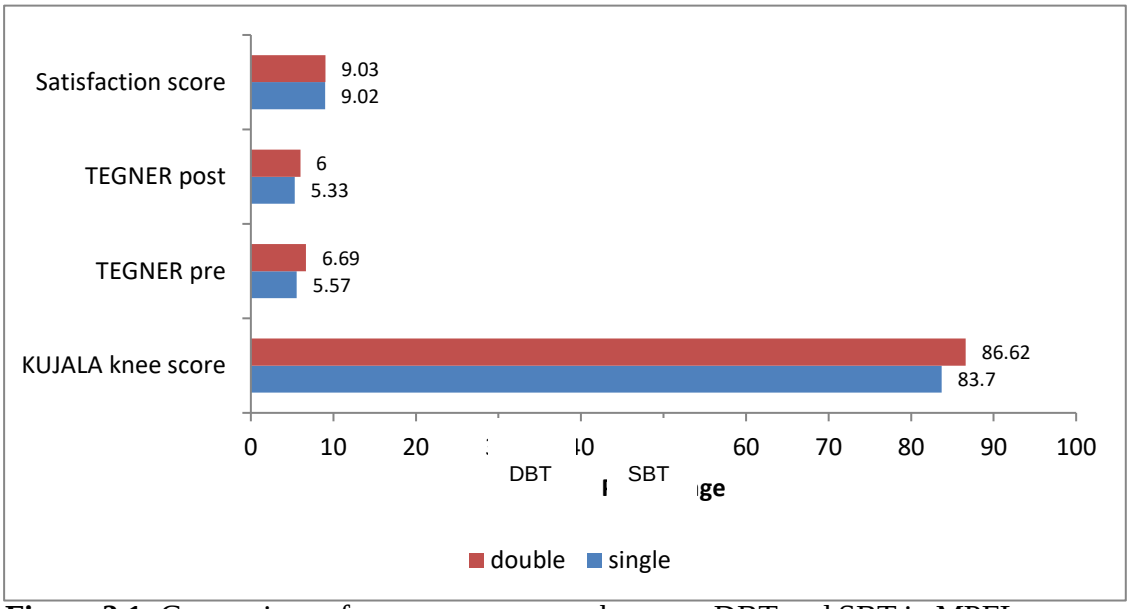

Figure 3.1: Comparison of outcome measures between DBT and SBT in MPFL reconstruction

Table 3.3: Comparison of patients undergoing SBT and DBT in MPFL reconstruction

Outcomes	**SBT Group (*n* = 46)**	**DBT group (*n* = 39)**	***p*-value**
Mean age at time of surgery (years)	25.78 (±11.440)	21.87 (±8.452)	0.081
Female	69.57% (n=32)	56.41% (n=22)	0.209
Mean BMI kg/m^2 (SD)	25.21 (±6.772)	25.19 (±4.898)	0.939
Mean follow up in months (SD)	79.17 (±36.316)	82.23 (±33.451)	0.690
Completed rehabilitation	73.91% (*n* = 34)	64.1% (*n* = 25)	0.328
Dislocation rate	17.39% (*n* = 8)	12.82% (*n* = 5)	0.810
Further surgery needed	10.87% (*n* = 5)	5.12% (*n* = 2)	0.445
Kujala knee score mean (SD)	83.7 (±13.546)	86.62 (±9.727)	0.265
Tegner activity score mean post-operative (SD)	5.33 (±2.109)	6 (±2.212)	0.155
Change in Tegner activity score mean (SD)	-0.24 (±2.396)	-0.69 (±2.002)	0.352
VAS satisfaction score mean (SD)	9.02 (±1.341)	9.03 (±1.308)	0.989

Table 3.4: Comparison of dislocation rate and revision surgery between DBT and SBBT in MPFL reconstruction

Outcome	**Category**	**SBT group (*n* = 46)**	**DBT group (*n* = 39)**	***p*-value**
Re-dislocation rate post-operatively	**Never**	82.61% (*n* = 38)	87.18% (*n* = 34)	0.810
	Once	6.52% (*n* = 3)	2.56% (*n* = 1)	
	More than once	10.87% (*n* = 5)	10.26% (*n* = 4)	
Further surgery needed post-operatively	**No**	89.13% (*n* = 41)	94.87% (*n* = 37)	0.445
	Yes	10.87% (*n* = 5)	5.13% (*n* = 2)	

3.1.3 Does the choice of the graft of MPFL reconstruction have an influence on patient outcomes?

When comparing the use of autograft (*n* = 76) *versus* allograft (*n* = 9) in MPFL reconstruction, there were no reported dislocations with the use of allograft, but this difference was not found to be statistically significant as indicated in Table 3.5. Table 3.6 refers to the PROMs between autograft and allograft MPFL reconstructions. Allograft reconstructions had higher mean Kujala scores (85.8 ± 17.634) (p = 0.845), less change in Tegner activity scores (-0.2 ± 3.153) (p = 0.750) and higher mean patient satisfaction scores (9.4 ± 0.882) (p = 0.314) when compared to autograft reconstructions, however these differences are not statistically significant.

Table 3.5: Comparison of dislocation rate between graft choices in MPFL reconstruction

Outcome	**Categories**	**Autograft (*n* = 76)**	**Allograft (*n* = 9)**	***p*-value**
Post-operative re-dislocation rate	**Never**	82.89% (*n* = 63)	100% (*n* = 9)	0.738
	Once	5.26% (*n* = 4)	0	
	More than once	11.8% (*n* = 9)	0	

Table 3.6: Comparison of outcome scores between graft choices in MPFL reconstruction

	Autograft (*n* = 76)	**Allograft (*n* = 9)**	***p*-value**
Age at time of surgery (mean years)	23.32 (±9.462)	29.67 (±15.362)	0.257
BMI kg/m^2	24.664 (5.329)	28.89 (±9.198)	0.044
Average follow up in months (mean)	85.54 (±32.966)	38.67 (±18.967)	0.001
Completion of post-operative rehabilitation	68.4% (*n* = 52)	77.8% (*n* = 7)	0.715
Never dislocated	82.9% (*n* = 63)	100% (*n* = 9)	0.738
Kujala knee score	85 (±11.28)	85.8 (±17.63)	0.845
Tegner activity score mean pre-injury	6.17 (±2.744)	5.33 (±3.640)	0.406
Mean change in Tegner activity score	-0.5 (±2.113)	-0.2 (±3.153)	0.750
Tegner activity score mean post-operative	5.70 (±2.148)	5.11 (±2.421)	0.447
Patient satisfaction VAS	9 (±1.36)	9.4 (±0.88)	0.314

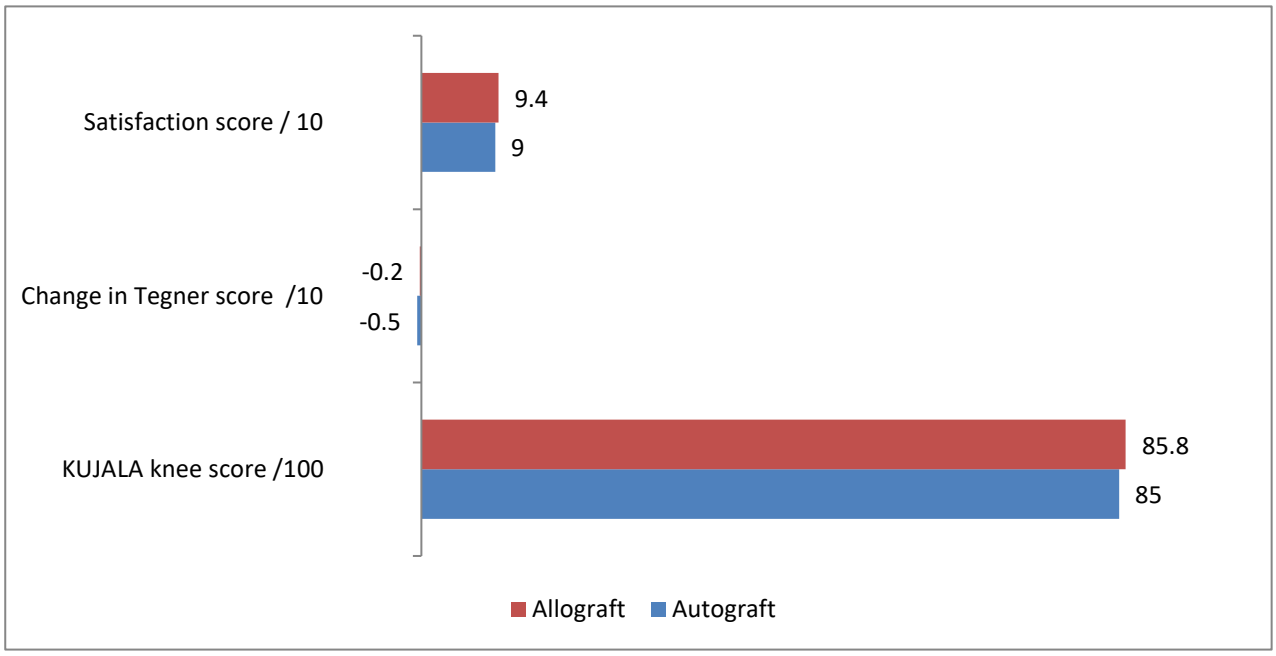

Figure 3.2: Comparison of outcome measures between the use of Allograft and Autograft

3.1.4 Do patient demographic differences have an influence on the success of MPFL reconstruction surgery?

When comparing the post-operative dislocation rate with regards to gender reported in Table 3.7, 14.81% (n = 8) female patients reported dislocating post-operatively compared to 16.13% (n = 5) male patients (p = 0.894). Male patients were found to have higher mean Kujala knee scores (p = 0.696), pre-injury Tegner activity score (p < 0.001), post-operative Tegner activity score (p = 0.011) and change in Tegner activity score (p = 0.024), but lower patient satisfaction VAS scores compared to female patients (p = 0.022). Comparison of the mean patient reported outcomes between male and female patients are summarised in Table 3.8. Compared to those who never had a re-dislocation, males are 1.77 times more likely than females to have one re-dislocation (p = 0.580), and females are 1.13 times more likely than males to have more than one re-dislocation (p = 0.870).

Table 3.7: Comparison of dislocation rate between gender

Outcome	Female (n = 54)	Male (n = 31)	p-value
Never dislocated	85.19% (n = 46)	83.87% (n = 26)	0.894
Dislocated once	3.70% (n = 2)	6.45% (n = 2)	
Dislocated more than once	11.11% (n = 6)	9.68% (n = 3)	

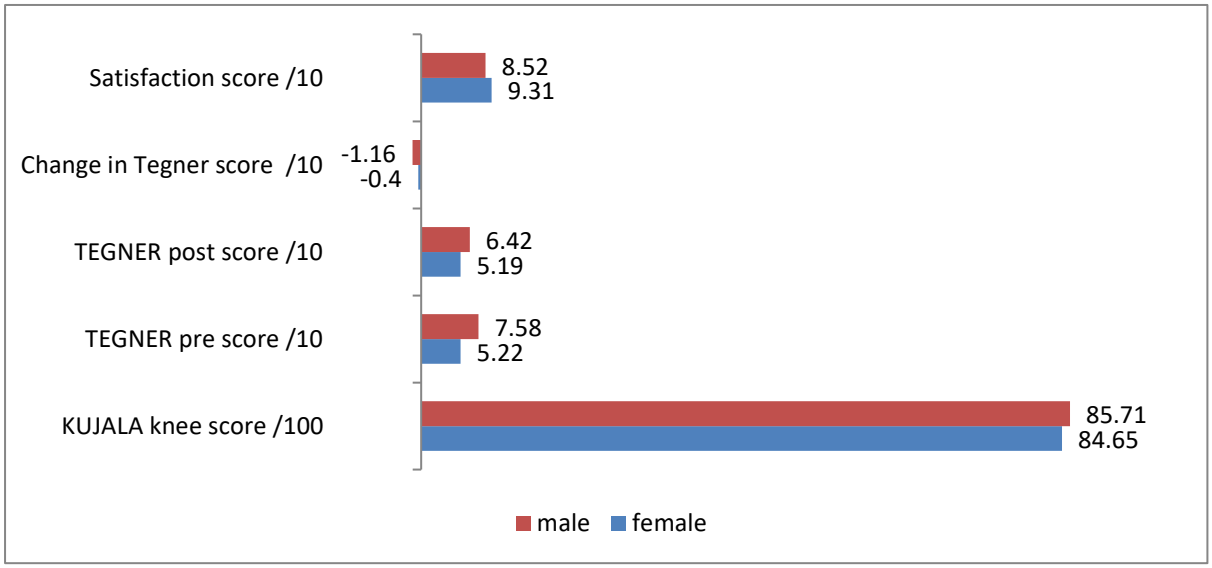

Figure 3.3: Comparison of outcome measures between gender

Table 3.8: Comparison of outcome scores between gender

Outcomes	**Male (*n* = 31)**	**Female (*n* = 54)**	***p*-value**
Completion of rehabilitation	28.8% (*n* = 17)	71.2% (*n* = 42)	0.027
Mean Kujala knee score	85.71 (±11.489)	84.65 (±11.489)	0.696
Tegner activity score mean pre-injury	7.58 (±1.893)	5.22 (±2.944)	<0.001
Tegner activity score mean post-operative	6.42 (±2.013)	5.19 (±2.146)	0.011
Change in Tegner activity score mean	-1.16 (±2.177)	-0.4 (±2.163)	0.024
Patient satisfaction VAS mean	8.52 (± 1.73)	9.31 (±0.907)	0.022

The age of patients was compared to the patient reported outcomes. There is a moderate negative correlation between age and the Kujala score, r = -0.423 ($p < 0.001$), pre-injury Tegner score r = -0.409 ($p < 0.001$), and post-operative Tegner score r = -0.377 ($p < 0.001$). Higher scores are associated with younger patients. There is a weak negative correlation between BMI and the Tegner score pre-injury, r = -0.275, (p = 0.013). Lower scores are associated with higher BMI. Table 3.9 summarises the associations between the outcome scores and age and BMI.

Table 3.9: Association between age and BMI with regards to outcome scores

Outcomes	**Age**		**BMI**	
	Pearson correlation	***p*-value**	**Pearson correlation**	***p*-value**
Kujala knee score	-0.423	<0.001	-0.143	0.204
Tegner activity score pre-injury	-0.409	<0.001	-.275	0.013
Tegner activity score post-operative	-0.377	<0.001	-0.193	0.084
Change in Tegner activity score	0.154	0.161	0.162	0.148
Patient VAS satisfaction score	-0.135	0.218	-0.061	0.588

3.1.5 Do patients undergoing MPFL reconstruction complete post-operative rehabilitation?

A significant 69% (*n* = 59) of patients reported that they had completed post-operative rehabilitation and were discharged from their rehabilitation program Table 3.10. Patients who had completed post-operative rehabilitation (22.78 years ± 9.171) had a younger mean age compared to patients who had not completed their post-operative rehabilitation (26.73 years ± 12.275), but not statistically significant (*p* = 0.104).

A significant number of male patients (*n* = 14), compared to female patients (*n* = 8), did not complete rehabilitation (*p* = 0.027) Table 3.8. Male patients are 2.9 times more likely not to complete post-operative rehabilitation compared to female patients.

Table 3.10: Number of patients who completed post-operative rehabilitation

	Frequency (%)		***n***	***p*-value**
	Not completed	**Completed**		
Post-op rehabilitation	26 (31)	59 (69)	85	< 0.001

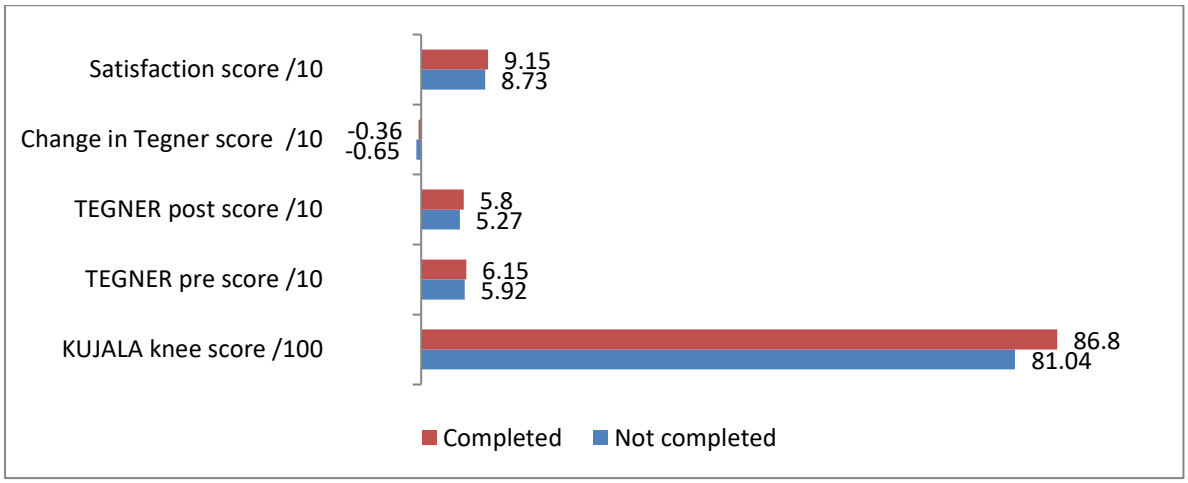

Figure 3.4: Comparison of outcome measures between patients completing rehabilitation and not completing rehabilitation

The re-dislocation rate of patients who had completed rehabilitation was 11.86% (n = 7) compared to the re-dislocation rate of patients who had not completed rehabilitation of 23.07% (n = 6), however no significant relationship was found (p = 0.359). Mean Kujala knee scores (86.80 ± 10.586), pre-injury Tegner scores (6.15 ± 2.929), post-operative Tegner scores (5.80 ± 2.140) and patient satisfaction scores (9.15 ± 1.311) were all higher for patients that completed post-operative rehabilitation compared to patients that did not complete post-operative rehabilitation, but only the difference between the mean Kujala knee scores was found to be statistically significant (p = 0.040). Patients were 2.6 times more likely to re-dislocate if rehabilitation was not complete compared to those who had completed rehabilitation. This finding was not statistically significant (p = 0.355).

Table 3.11: Comparison of whether post-operative rehabilitation effects the outcome measures

Outcomes	**Completed (n = 59)**	**Not completed (n = 26)**	***p*-value**
Dislocation rate	11.86% (n = 7)	23.07% (n = 6)	0.359
Kujala knee score mean	86.80 (±10.586)	81.04 (±14.05)	0.040
Tegner activity score mean pre-injury	6.15 (±2.929)	5.92 (±2.667)	0.733
Tegner activity score mean post-operative	5.80 (±2.140)	5.27 (±2.237)	0.305
Change in Tegner activity score mean	-0.36 (±2.310)	-0.65 (±2.038)	0.572
Patient satisfaction VAS mean	9.15 (±1.311)	8.73 (±1.313)	0.176

CHAPTER 4

4. DISCUSSION

4.1 Demographics

MPFL reconstruction is a reliable procedure that is associated with favourable outcomes in addressing lateral patella instability, although there is diversity with regards to certain technical aspects of the procedure (6,8,9,12,14)**.** This cohort of patients expressed similar age and gender profiles reported in previous studies on MPFL reconstruction. The mean age of 24 years and 63% female composition would be in keeping with multiple studies within the literature, that patella instability occurs mostly in the young population with a female predominance (2,11,17,30,53,54).

4.2 Outcomes for entire cohort of patients

The overall mean Kujala knee score of 85 and post-operative Tegner activity score of 5.6 were both favourable and comparable to the literature, as a review by Kang et al. (2019) reported a range of mean post-operative Kujala scores of 80.46 ± 3.59 to 96.0 ± 5.2, which is similar to a review by Mackay et al. (2014) reporting a mean post-operative Kujala score of 87.77 (12,30). Wang et al. (2013) did report use of a subjective questionnaire score (17). To the authors knowledge the VAS for patient satisfaction described in arthroplasty studies, has not been utilised before in MPFL reconstruction studies, hindering the comparison of this outcome to previous studies (17,52).

The overall re-dislocation rate of 15.29% was higher than previous publications (12,30). This may be due to the subjective nature in which follow up questionaries were utilised more than clinical assessments, and therefore perceived instability may be over reported as a patella dislocation. Enderlein et al. (2014) described a dislocation rate of 4.6% similar to results found in systematic reviews by Kang et al. (2019), Schneider et al. (2016) and Mackay et al. (2014) (2,12,30). A systematic review by Cregar et al. (2022) reported a mean failure rate of recurrent post-operative instability of 4.3%, with a range of 0 – 16.6% (21). Enderlein et al. (2014) further reported that 39% of the 224 patients included in the study had experienced one or

multiple episodes of patellar instability, with 11% reporting that the subjective patellar instability was present for more than a month (53). Due to the retrospective nature of the study, differentiating patella dislocation from perceived instability was not possible as the information was not available. This lack of clarification between a dislocation and perceived instability could explain the increased re-dislocation rate of 15.29% reported in this cohort of patients which is closer to that reported by Enderlein et al. (2014), especially considering that the post-operative Kujala knee scores were favourable and in keeping with the literature (53).

Another contributing factor to the increased re-dislocation rate could be related to the fact that the mean follow-up period of 80.6 months is greater than most other studies. In a review by Kay et al. (2021) the mean follow-up period was 35.6 months from various studies, and Schneider et al. (2016) reported a mean follow up of 36.8 months in a systematic review and meta-analysis (2,11). Wang et al. (2013) reported significantly higher instability rates for single bundle MPFL reconstruction with longer follow up periods, when they compared 12-month follow up to 48 month follow up (17).

Anatomical variances including increased TT-TG distance, trochlear dysplasia and trochlear bump height have been reported as risk factors for patella re-dislocation and poor patient reported outcomes post MPFL reconstruction (21). These risk factors were not collected for patients included in the study and may explain the high re-dislocation rate. Due to the increased reported re-dislocation rate, assessing the need for revision surgery amongst patients reporting post-operative dislocation was included. The rate of patients who reported re-dislocation and requiring revision surgery was 3.5%, which is similar to the previously mentioned re-dislocation rates and the pooled reoperation risk of 3.1% reported by Schneider et al. (2016) (2).

4.3 Comparison of SBT and DBT in MPFL reconstruction

Comparison of the SBT and the DBT in this cohort of patients indicated that all outcome measures are slightly more favourable for patients undergoing DBT reconstruction compared to SBT reconstruction, however no statistical significance was found regarding these differences. This is similar to multiple publications with similar population sizes, and in keeping with the results reported by various systematic reviews (2,12,30,55). Ercan et al.

(2021) found no significant difference in clinical and functional results between DBT and SBT in MPFL reconstruction, although the Kujala knee scores and Tegner scores were slightly more favourable for the DBT (55). The findings in this study agree with the previous mentioned publications, as well as with the findings of Astur et al. (2015) reporting on follow up periods of 2 and 5 years (10). That is Kujala knee scores were more favourable for the DBT, compared to SBT, although this difference was not statistically significant (10).

Specific post-operative complications were not recorded, which would give more additional information comparing the techniques, as the DBT and SBT have been associated with different outcomes and complications. It has also been highlighted that the anatomical location of the graft fixation as well as the positioning of graft tensioning are fundamental in the outcomes of MPFL reconstruction and preventing post-operative complications (2,14,21). These were not recorded in the study and need to be kept in mind that these surgical technique differences could affect the reported outcomes.

4.4 Comparison of the use of autograft and allograft in MPFL reconstruction

MPFL reconstructions utilising allograft resulted in no dislocations in this cohort of patients, although possibly due to the low numbers involved this was not found to be statistically significant when compared to autograft. The Kujala knee scores and Tegner activity scores were slightly more favourable for the allograft group, but not statistically significant. Flanigan et al. (2020) compared allograft to autograft and found no significant difference with patient reported outcomes and recurrent dislocation rate (38). In the systematic review published by McNeilan et al. (2018), the re-dislocation rate is lower for allograft compared to autograft, although it was found not to be statistically significant which is in keeping with the findings of this study (39). In the systematic review and meta-analysis by Migliorini et al. (2022) there was no difference reported regarding Kujala knee scores but the use of allograft resulted in a statistically significant lower rate of dislocations (56).

In the current cohort of patients, there was a large discrepancy between the numbers of those within the allograft compared to autograft group, and a difference noted with BMI and follow up period between the two groups. The results are in keeping with the literature; however, the differences in the groups should be kept in mind when interpreting the findings.

Allograft does not result in inferior results when comparing PROMs and dislocation rates, and allograft seems a reasonable substitute to autograft in agreement with previous studies (11,39,56). Other differentiating factors should be considered in the decision between allograft and autograft, such as the difference in surgical time, the morbidity associated with autograft harvesting and the risk of allogenic reaction or infection with the use of allograft (37). There is an increased cost with the use of allograft which has not been shown to be fully compensated by the decreased surgical time (38). Irradiation and sterilisation technique affect the properties of the allograft, and this needs to be considered (40). All the allografts used in the MPFL reconstructions in this cohort of patients were irradiated and sterilised.

4.5 Assessment of demographic factors and BMI on outcomes post MPFL reconstruction

Age older than 30 years and BMI greater than 30 kg/m^2 have been reported as risk factors for poor outcomes post MPFL reconstruction by a large prospective study of 224 patients undergoing MPFL reconstruction, although this study reported on a DBT only (53). Hiemstra and Kerslake (2019) agree that age at the time of surgery has a significant effect on patient reported outcomes, and Žlak et al. (2022) reported that increased age and higher BMI negatively affect outcomes (54,57). This is in keeping with our findings of the entire cohort of a negative correlation between age and the Kujala knee score and Tegner score and negative correlation between BMI and Tegner score. Enderlein et al. (2014) found male patients had higher Kujala knee scores and Žlak et al. (2022) reported female gender negatively correlated with Tegner scores (53,57). This is similar to the findings of this study that male patients obtained higher Kujala knee scores and Tegner activity scores even though these were not found to be statistically significant. The comparison of the gender profile indicated that there was no significant difference found when assessing dislocation rate, which is similar to that reported by Astur et al. (2015) and a systematic review by Fancher et al. (2021) (10,58).

4.6 Effect of rehabilitation on outcomes post MPFL reconstruction

Within the entire cohort of patients, it was found that all patients underwent rehabilitation but only 69.4% had reported to have completed a rehabilitation program and were discharged. Patients that reported completion of rehabilitation also had more favourable Kujala knee scores, Tegner activity scores and VAS satisfaction scores, although only the Kujala scores were statistically significant. This could possibly emphasise the importance of rehabilitation in MPFL reconstruction with achieving optimal outcomes and is consistent with current literature suggesting that rehabilitation post MPFL reconstruction does improve patients return to function regardless of the surgical technique (59).

This was a retrospective study; therefore, it is impossible to confidently report the reason for patients not completing the rehabilitation. This could be an important missing factor affecting these results, as there may be a possibility that patients did not feel the rehabilitation was benefiting them and that the poor outcomes were already determined by the initial surgical procedure. Including these details could aid in explaining the difference noted between gender with completion of rehabilitation. Since post-operative rehabilitation has been reported to play a role in post-operative return to function, it can be fair to conclude that ensuring patients complete their post-operative rehabilitation is vital in achieving optimal outcomes (59).

Another factor to consider is that the rehabilitation program was not standardised due to the nature of the private health care sector and the freedom of choice available to patients when choosing their health care provider for post-operative rehabilitation. There was also no recording of the details of the rehabilitation programmes patients underwent or how long the rehabilitation process took post operatively. There is no gold standard reported regarding post-operative rehabilitation protocols and exercise interventions, although 4 phases with goals of each phase have been described (59–61). Patients heal at different rates, but following goals within the four phases allows adequate and safe progression of rehabilitation, with a return to sport of a mean 6.7 months according to a review by Platt et al. (2022) (60,62). Details of rehabilitation including the time-frame are important to note as they could affect the outcome measures used in this study, however this study was retrospective and this information was not available.

4.7 Limitations

- This was a retrospective study and there was information from patient records that was not available at the time of review, and 26.72% of patients were lost to follow up with no post-operative outcome measures available.
- The study included an orthopaedic surgery association practice with three orthopaedic surgeons, therefore the total numbers included in the sample size is fairly-low for statistical purposes, however the sample size is similar to other previous publications assessing MPFL reconstruction.
- The study site included an orthopaedic practice within the private health care sector and this may have an effect on selection bias.
- There was no standard time period of follow up but a wide range from 1 year to 10 years. Standardising the follow up period is needed in future studies.
- Although completion of post-operative rehabilitation was assessed, there was no standardised rehabilitation protocol or standardised time-period of rehabilitation reported. Difference in rehabilitation protocols may affect PROMs and would be better assessed with prospective studies with standardised rehabilitation protocols.
- Physiological and anatomical variances such as hyperlaxity and trochlear dysplasia, trochlear bump, patella alta and TT-TG distances have been reported as risk factors for re-dislocation and poor PROMs post-operatively, and these were not recorded in the study.

4.8 Recommendations

Based on the results from this study, these are the recommendations:

- Both DBT and SBT are adequate options for MPFL reconstruction as both result in similar outcomes. Further prospective high-powered studies, taking into consideration all contributing factors possibly affecting outcomes are needed to determine which technique is optimal. These factors include but are not limited to patient anatomy, surgeon training and graft-osseous fixation options available.
- Autograft and allograft are adequate options to be used in MPFL reconstruction providing similar outcomes. Again, it can be recommended that future prospective high-powered studies that consider all factors that affect outcomes are needed in order to isolate the effect of graft choice and determine the answer of which graft is optimum.

Until then the choice of graft should be guided by what is available, and the known complications of each graft choice.

- Age has a negative correlation with outcomes; therefore any delay in surgery should be avoided. Delay in surgery may also result in damage to articulating cartilage from repeated dislocations, which is also associated with unfavourable outcomes.
- Female gender is a non-modifiable risk factor for poorer post-operative outcomes, and this needs to be taken into consideration when managing these patients.
- Rehabilitation has been shown to affect post-operative outcomes; therefore, emphasis on completing adequate rehabilitation must be conveyed to patients. Further prospective high-powered studies are required to determine the optimum rehabilitation protocol including time-frame.

CHAPTER 5
CONCLUSION

Patella instability usually occurs in the young active population with a larger female predominance. Many surgical techniques have been described to address patellar instability and MPFL reconstruction, with the many technical variations, has become the most commonly utilised technique. This retrospective review of a cohort of patients found similar results reported in the literature. MPFL reconstruction utilising either the DBT or SBT with allograft or with autograft result in similar favourable outcomes in addressing patella instability. Increased age at the time of surgery and increased BMI are associated with poorer outcomes and these factors need to be taken into consideration for optimising patients prior to surgery. Not completing post-operative rehabilitation negatively affects outcomes, and emphasis on completing rehabilitation needs to be communicated to patients.

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APPENDIX A **Study number:**_____

Comparison of the success and patient outcomes of medial patellofemoral ligament reconstruction techniques

PATIENT DATA CAPTURE SHEET

Date: _____

Patient Name:_____

Contact number:_____

Study Number:_____

Study group:_____

APPENDIX B **Study number:_____**

Comparison of the success and patient outcomes of medial patellofemoral ligament reconstruction techniques

STUDY NUMBER DATA CAPTURE SHEET

Study number:_____ **Age:** _____ years **Gender:** MALE FEMALE

Date of surgery: _____

Articular cartilage comment: Patella_____ Trochlear_____

Number of bundles: Single bundle Double bundle

Type of graft: **Autograft**: Gracilis semitendinosis quads

Allograft: Tib Ant Peroneus longus semitendinosis achilles

Synthetic: Leeds Keio Fibre tape Dacron Other:_____

Type of fixation:

Patella: Bone tunnel + suture anchors interference screw (swivelok)

Femur: Inteference Screw Biotenodesis screw Suture anchor Staple

Post-operative rehabilitation completed: YES NO

Post-op time of assessment: _____ Months

Follow up Kujala score: _____/100 **Satisfaction score VAS: ____/10**

Tegner Score: Pre-op _____: **Post-op highest: _____Post op Current:_____**

Complications: infection DVT wound breakdown

Anterior knee pain loss of movement re-dislocation

Second procedure: revision MPFL lateral release removal hardware

Wound debridement arthroscopic patella debridement removal loose body

Other: _____

APPENDIX C **Study number:**_____

Comparison of the success and patient outcomes of medial patellofemoral

KUJALA KNEE QUESTIONNAIRE **TOTAL SCORE:** _____

1. _____**LIMP:** a) None 5 b) Slight or periodic 3 c) Constant 2

2. _____**SUPPORT:** a) Full support without pain 5 b)Painful 3 c)Unable to weight bear 0

3. _____**WALKING:** a)unlimited 5 b) >2km 3 c) 1-2 km 2 d) Unable 0

4. _____**STAIRS:** a)No difficulty 10 b) Slight pain with descending 8
c) Pain with ascending and descending 5 d) unable 0

5. _____**SQUATTING:** a) No difficulty 5 b)Repeated squatting painful 4
c)Painful each time 3 d) Possible with partial weightbearing 1 e)Unable 0

6. _____**RUNNING:** a)No difficulty 10 b)Pain after more than 2km 8
c) Slight pain from the start 6 d) Severe pain 3 e) Unable 0

7. _____**JUMPING:** a) No difficulty 10 b)Slight difficulty 7 c)Constant pain 2
d)Unable 0

8. _____**PROLONGED SITTING WITH KNEE FLEXED:** a) No difficulty 10
b)Pain after exercise 8 c) Constant pain 6 d)Severe pain 4 e)Unable 0

9. _____**PAIN:** a) None 10 b) Slight and occasional 8 c)Interferes with sleep 6
d) Occasionally severe 3 e) Constant and severe 0

10. _____**SWELLING:** a) None 10 b) After severe exertion 8
c) After daily activities 6 d) Every morning 4 e)Constant 0

11. _____**ABNORMAL PAINFUL PATELLA MOVEMENTS:** a) None 10
b) Occasional in sports activity 6 c) Occasional in daily activities 4
d) at least one dislocation 2 e) More than two dislocations 0

12. _____**ATROPHY OF THIGH:** a) None 5 b) Slight 3 c) Severe 0

13. _____**FLEXION DEFICIENCY:** a) None 5 b) Slight 3 c) Severe 0

14. _____**TOTAL SCORE**

APPENDIX D **Study number:**_____

Comparison of the success and patient outcomes of medial patellofemoral

TEGNER ACTIVITY SCALE **TOTAL LEVEL:** _____

Level 10 Competitive sports- soccer, football, rugby (national elite)

Level 9 Competitive sports- soccer, football, rugby (lower divisions), ice hockey, wrestling, gymnastics, basketball

Level 8 Competitive sports- racquetball or bandy, squash or badminton, track and field athletics (jumping, etc.), down-hill skiing

Level 7 Competitive sports- tennis, running, motorcars speedway, handball, recreational sports- soccer, football, rugby, bandy, ice hockey, basketball, squash, racquetball, running

Level 6 Recreational sports- tennis and badminton, handball, racquetball, down-hill skiing, jogging at least 5 times per week

Level 5 Work- heavy labour (construction, etc.) Competitive sports- cycling, cross-country skiing, Recreational sports- jogging on uneven ground at least twice weekly

Level 4 Work- moderately heavy labour (e.g. truck driving, etc.)

Level 3 Work- light labour (nursing, etc.)

Level 2 Work- light labour Walking on uneven ground possible, but impossible to back pack or hike

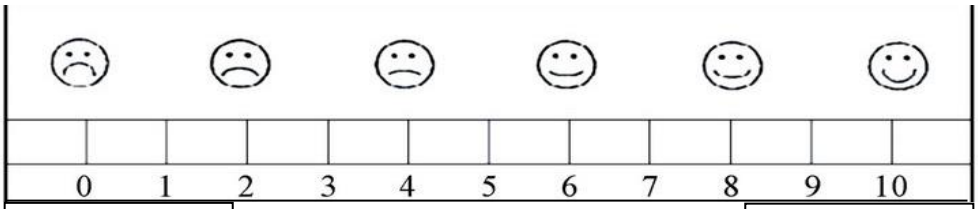
Level 1 Work- sedentary (secretarial, etc.)

Level 0 Sick leave or disability pension because of knee problems

APPENDIX E **Study number:**_____

Comparison of the success and patient outcomes of medial patellofemoral

VISUAL ANALOGUE SCALE – SATISFACTION OF PROCEDURE



Completely unsatisfied	Completely Satisfied

After your knee surgery how much would you rate your level of satisfaction?

Please indicate your level of satisfaction of the outcome of your surgery by marking a vertical line on this 10cm line above, where 0 would indicate you are completely unsatisfied with the outcome of your procedure, and 10 would indicate you are completely satisfied with the outcome.

APPENDIX F

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr PR Almeida

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M200830

NAME: (Principal Investigator)	Dr PR Almeida
DEPARTMENT:	School of Clinical Medicine Department of Surgery Division of Orthopaedic Surgery Medical School University
PROJECT TITLE:	Comparison of the success of medial patellofemoral ligament reconstruction techniques
DATE CONSIDERED:	28 August 2020
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr B Gelbart and Professor P Firer
APPROVED BY:	CB Penny Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	23 November 2020

This clearance certificate is valid for 5 years from the date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the 3rd Floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.
I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **August** and will therefore reports and re-certification will be due early in the month of **August** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

25/11/2020
Date

APPENDIX G

BRADLEY R. GELBART
MBBCh (Wits) DA (SA) FC Ortho (SA)
PR Number: 327220

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25 June 2020

To whom it may concern

Re Application for Ethics for Research protocol

Comparison of the success and patient outcomes of medial patellofemoral ligament reconstruction techniques

I confirm that permission has been granted for Dr R. Almeida to access my patients records at the Linksfield Orthopaedic Sports and Rehabilitation Centre and Rosebank Centre for Sports Medicine and Orthopaedics for his research.

He has been advised to respect general protocols on protection of information and patient rights

If you have any further requests please feel to contact me

Your Sincerely

Dr Brad Gelbart
Consultant Orthopaedic Surgeon

DR. MATTHEW STREET
ORTHOPAEDIC SURGEON
Pr No. 0573299

30 June 2020

To whom it may concern

Re: Application for Ethics for Research protocol

Comparison of the success and patient outcomes of medial patellofemoral ligament reconstruction techniques

I confirm that permission has been granted for Dr R. Almeida to access my patients records at the Linksfield Orthopaedic Sports and Rehabilitation Centre and Rosebank Centre for Sports Medicine and Orthopaedics for his research.

He has been advised to respect general protocols on protection of information and patient rights.

If you have any further requests please feel to contact me.

Your Sincerely

Dr MR Street

Orthopaedic surgeon

PROF. PONKY FIRER

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8 July 2020

TO WHOM IT MAY CONCERN

Re: Application for Ethics approval for Mmed degree. Title : **Comparison of the success and patient outcomes of medial patellofemoral ligament reconstruction techniques**

I confirm that permission has been granted for Dr R Almeida to use my patients' notes for his research. In addition I confirm that all patients have signed an agreement to allow the use of this information for research purposes.

Yours sincerely

Professor Ponky Firer