Original Article

Outcomes of Allograft Medial Patellofemoral Ligament Reconstruction in Children and Adolescents with Hypermobility

Gautam Reddy, Prabhnoor Singh Hayer[1], Saif Ullslam, Nisarg J Mehta, Hafiz Javaid Iqbal[2], Gareth Stables [1], Nicholas G Barton-Hanson[3]

Liverpool University Hospitals, [3]Alder Hey Children's Hospital, Liverpool, [1]Warrington and Halton Teaching Hospitals, Warrington, [2]Countess of Chester Hospital, Chester, England

Abstract

Introduction: Medial patellofemoral ligament (MPFL) reconstruction is used to treat patellofemoral instability either in isolation or in combination with other procedures. Use of allograft can preserve native tissue in children and can be advantageous in patients with connective tissue disorders, including ligamentous laxity. There is limited evidence regarding functional outcomes of allograft MPFL reconstruction in children and adolescents. This study aimed to assess the short to mid-term results of allograft MPFL reconstruction in children with hypermobility at a tertiary pediatric orthopedic center. **Materials and Methods:** We retrospectively reviewed all children and adolescents who had undergone allograft MPFL reconstruction over 4 years. The primary outcome measure was the validated Kujala score for patellofemoral disorders. The secondary outcome measures included complications such as redislocation of the patella needing revision surgery. Patients with hypermobility were quantified using Beighton criteria. Statistical analysis was performed using Graph Pad Prism (V6). **Results:** Between 2012 and 2016, the senior author performed 76 allograft MPFL reconstructions in 57 patients. Nineteen patients had bilateral surgery. The mean age was 14 (7–16) years with a female: male ratio of 3:1. The mean Beighton score was 7. Hypermobility was part of a syndrome in ten patients. The mean follow-up was 3 (1–4) years. Nine patients had trochleoplasty and six patients had tibial tubercle osteotomy, in addition to allograft MPFL reconstruction. These fifteen patients, who had additional procedures, were excluded during the analysis of the outcome measures. The mean Kujala score was 89 (80–100). The overall complication rate was 11% (9/76). These included two patella fractures and seven (9%) patients with recurrent instability needing revision surgery. There was no significant difference in complication rates between syndromic and nonsyndromic patients ($P = 0.9$). **Conclusion:** Our study shows excellent short to mid-term functional outcomes of allograft MPFL reconstruction in children and adolescents with hypermobility.

Keywords: *Allograft, children and adolescents, hypermobility, medial patellofemoral ligament reconstruction, patella dislocation*

Introduction

Patellofemoral instability is one of the most common knee conditions in children seen by pediatric orthopedic surgeons.[1-3] The recurrence rate after the first dislocations is relatively high in children[4] and results in significant functional limitations. Patellar instability can be due to bony or soft-tissue problems or a combination. Various factors including trochlear dysplasia, skeletal immaturity, patella alta, increased tibial tuberosity-trochlear groove (TT-TG) distance, torsional abnormalities, and a history of contralateral patellar dislocation have been found to be of significance in recurrence after first-time patellar dislocations.[5,6] For recurrent patellar instability not responding to conservative measures, surgical management is warranted to improve pain and function. This can be challenging in children with ligamentous laxity, open physis, and rehabilitation issues.[7] With a thorough preoperative clinical and radiological assessment, it is possible to identify various pathoanatomic issues that predispose to patellar instability, and these need to be considered during surgical planning. However, in pediatric patients, bony corrections may not be suitable before skeletal maturity because of risk of growth plate injury associated with procedures such as trochleoplasty and tibial tabernacle osteotomy; hence soft-tissue procedures are favored if the surgery cannot be delayed.

Medial patellofemoral ligament (MPFL) is a critical medial restraint and is commonly injured in lateral patellar

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Address for correspondence:
Dr. Gautam Reddy, Liverpool University Hospitals NHS Foundation Trust, Liverpool, England.
E-mail: gautamreddy20@yahoo.co.uk

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dislocation.[8] Reconstruction of this ligament is an important and well-established soft tissue patella stabilizing procedure.[1,2,9-14] In children, allograft MPFL reconstruction can preserve native tissue and can be advantageous for patients with ligamentous laxity and connective tissue disorders. There are only limited numbers of studies reviewing the use of allograft in hypermobile children for MPFL reconstruction with small numbers.[15] We aim to evaluate the outcomes of allograft MPFL reconstruction in children with hypermobility for recurrent patellar instability at our tertiary care center.

Materials and Methods

We retrospectively reviewed all children and adolescents who underwent allograft MPFL reconstruction in our unit from January 2012 to December 2016. The operating theater database was used to identify the patients. We reviewed the patients' clinical notes, including the operative records, radiological investigations, and rehabilitation details. Only those with a history of traumatic patella dislocation were included.

Preoperative assessment

In the outpatient clinic, all the patients were thoroughly assessed clinically followed by weight-bearing AP (anteroposterior), lateral, and skyline radiographs of the knee. Patients who presented after the first dislocation after trauma were treated nonoperatively and referred for physiotherapy assessment and treatment. Among those with subsequent dislocations as a part of preoperative planning, all underwent magnetic resonance imaging and computed tomography scans to assess any bony or soft tissue structural abnormalities such as patellar height, trochlear dysplasia, MPFL integrity, and any intra-articular injuries.

The patients were clinically examined for joint hypermobility, and Beighton score was used to quantify the joint hypermobility. The rotation profile of both lower limbs was assessed clinically. An individualized treatment plan was designed for each patient whether to undergo only MPFL reconstruction or additional procedures in the form of tibial tuberosity transfer and/or trochleoplasty depending on clinical and radiological findings and child's skeletal maturity.

Operative technique

MPFL reconstruction was performed using a fresh-frozen allograft obtained from the NHS Blood and Transplant Tissue Services, Liverpool. The procedure was performed through a two-skin incision technique. A 3-cm vertical skin incision was performed over the superior medial one-third of the patella. The graft was passed through a transverse tunnel in the patella, and a 6 mm × 20 mm interference screw (Smith and Nephew Biosure) was used to fix one end of the graft [Figure 1].

The graft was then passed extra-articularly after developing a tunnel between the medial patellar retinaculum and joint capsule. On the femoral side, the landmarks of adductor tubercle and medial epicondyle were felt, and a 2-cm skin incision was made between the landmarks. A medial to the lateral bone tunnel was created at the site of the femoral attachment of MPFL. The tunnel was directed 20° distally and anteriorly to protect the undulated physis, but in patients who achieved skeletal maturity, the tunnel can be directed proximally. The second end of the graft was passed and fixed with a 6 mm × 25 mm interference screw (Smith and Nephew Biosure) after achieving proper patellar tension in 30° of flexion [Figures 2-5]. We also do not routinely use radiographs to locate the femoral insertion point of MPFL.

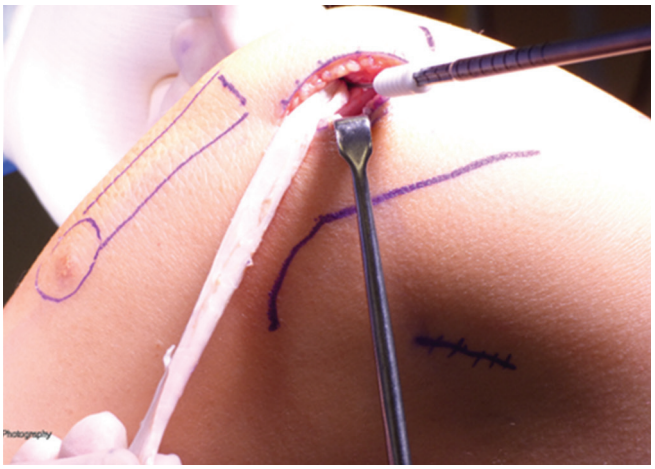

Figure 1: Allograft fixation into the patella at the junction of the middle and upper third

Sulcus deepening trochleoplasty was performed additionally in patients with severe trochlear dysplasia (classification as per Dejour) who had attained skeletal maturity. An osteochondral flap was raised at the trochlea, sulcus was deepened, and the cartilage was reapplied and held in place with vicryl suture [Figure 6].

In addition to MPFL reconstruction, distalizing tibial tubercle osteotomy was performed in skeletally mature patients with patella alta [Figure 7]. Elmslie-Trillat medializing osteotomies were performed for TT-TG distances of 20 mm or more. In Figure 7c, one can see the radiolucent drill holes of allograft MPFL graft position on the patella and the distal femur in the lateral view of the radiograph. The screws used were bio-absorbable and are not radiopaque.

Rehabilitation

The patients underwent a rehabilitation program under the supervision of a trained physiotherapist. For the first 6 weeks after surgery, the emphasis was on recovering a full range of movement. Full weight-bearing was allowed with walking aids while quadriceps control was regained.

A range of movement brace was only used to protect distalizing/medializing tubercle osteotomies until they had

Figure 2: Guidewire passed at MPFL femoral attachment site. MPFL: Medial patellofemoral ligament

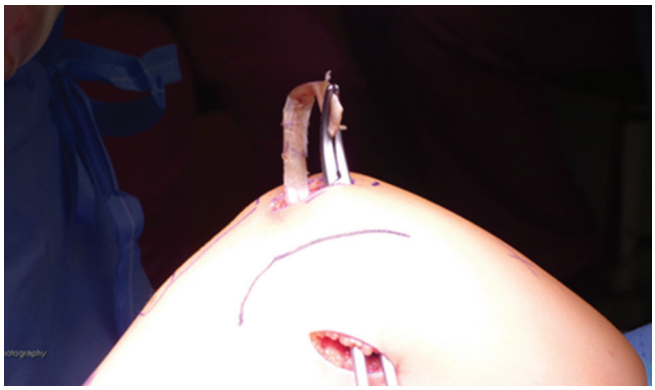

Figure 4: Passage of the graft between patella retinaculum and joint capsule

Figure 3: Femoral tunnel drilled

Figure 5: Fixation of the graft in the femoral tunnel

healed 6 weeks after surgery. After 6 weeks, balance and proprioceptive work were started along with progressive strengthening exercises for the quadriceps and hamstrings. If strength and core control were symmetrical at 3 months after surgery, sporting activities were gradually reintroduced.

Postoperative regimen

Postoperatively, patients were seen in the clinic at 2 weeks, 6 weeks, 3 months, 1 year, and then yearly. Patients who were not skeletally mature were followed up until they had stopped growing because of the risk of the graft becoming oblique with femoral growth, causing recurrent patella instability. A Kujala score was completed at the final follow-up. Those who could not fill the scores in the clinic were sent scores in the post. Statistical analysis was performed using GraphPad Prism (V6).

Results

During the study period, the senior author performed 76 allograft MPFL reconstructions in 57 patients [Figure 8]. Nineteen patients underwent bilateral sequential surgery. The mean age was 14 years (range 7–16). There were more female patients (female-to-male ratio of 3:1). Patients' ligamentous laxity was quantified using the Beighton score,[20] and the mean score was 7.

Hypermobility was part of a syndrome in ten patients. Among these, three patients had Down's syndrome, two had Ehler–Danlos syndrome, two had cerebral palsy, one Jacobsen syndrome, and two had severe learning difficulties.

Nine patients had trochleoplasty along with allograft MPFL reconstruction. Three patients had medial displacement tibial tubercle osteotomy (Elmslie–Trillat osteotomy) due to increased TT-TG distance, and a further three patients had distalization of the tibial tubercle for patella alta.

Kujala score was used as a patient-reported outcome measure. Total Kujala score ranges from 0 to 100, with high scores indicating excellent outcome. The developer reported average values of 99.9 for healthy controls, 82.8 for patients with anterior knee pain, and 62.2 for patients with patella instability.[22]

We excluded the patient who underwent associated procedures (trochleoplasty and tibial tubercle osteotomy) while calculating our primary and secondary outcome measures. The mean postoperative Kujala score in our series was 89 (range 80–100) for the patients who underwent isolated allograft MPFL in non-syndromic patients at

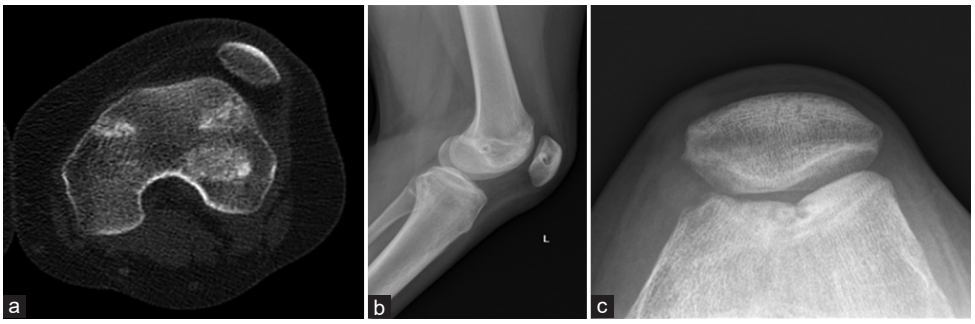

Figure 6: Trochleoplasty and allograft MPFL reconstruction. (a) Shallow trochlea. (b and c) postoperative radiographs

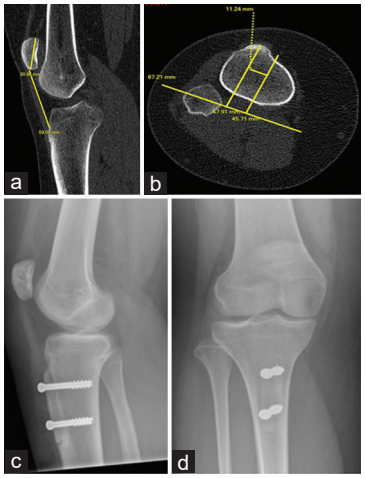

Figure 7: Patient with patella alta. Allograft MPFL reconstruction and distalization of the tibial tubercle. (a) Insall–Salvati index. (b) TTTG distance. (c and d) Postoperative lateral and AP radiographs. MPFL: Medial patellofemoral ligament, TT-TG: Tibial tuberosity trochlear groove

12 months after the procedure. In some of the syndromic group, it was difficult to apply the score as they were unable to perform some of the activities specified in the Kujala score, due to their physical and mental limitations related to the syndromes even before the surgery. So, the Kujala score was not able to apply to this group and was not collected.

At 1-year follow-up during the time of collection of Kujala score, we also asked the patient to report about the satisfaction of the procedure, by giving the following options: very satisfied/somewhat satisfied/neither satisfied nor dissatisfied/somewhat dissatisfied/very dissatisfied.

All the patients in both groups reported that they are very satisfied with the surgical outcome. The nineteen patients who had bilateral surgery had one side at a time. As these patients were very satisfied with the procedure on one side, they elected to proceed with surgery on the other side.

The mean follow-up was 3 years (range 1–4 years). The overall complication rate was 11% (9/76). These included two patella fractures that were treated with tension band wiring. Seven patients (9%) required revision surgery due to recurrent instability; this was due to the femoral growth causing allograft MPFL failure. There was no significant difference in complications between syndromic and nonsyndromic patients (P = 0.9). None of the patients developed deep infection or arthrofibrosis.

Discussion

Managing recurrent patella dislocation in children and adolescents is challenging. Because of their level of physical activity, patellar instability and knee pain cause considerable disability in this age group. The presence of immature bone adds to the challenge of surgical management as the femoral insertion site of the graft is very close to the physis. Any injury to the physis may cause growth disturbances. Moreover, as the distal femur grows, the graft can stretch out, causing recurrent instability.

In those patients who had additional structural abnormalities, performing a tibial tubercle osteotomy and trochleoplasty is not a favored first-line surgical option because of the growing bone and open growth plates. It has been widely accepted in these patients to perform staged reconstructions, with soft tissue procedures initially, and once the child attains skeletal maturity and if symptoms persist in performing the additional bony procedure.

Our study group included patients with ligamentous laxity exclusively. Joint hypermobility is a clinical sign, not a diagnosis. Hence, recognizing joint hypermobility does not allow the clinician to make a diagnosis, but instead may prompt additional assessment. Joint hypermobility is quite often underestimated by the clinicians; even in the literature, it is quoted widely that up to 2%–34% of males and 6%–57% of females have joint hypermobility.[16] Recent advances in genetic testing found collagen defects in this group of patients.[17,18] Therefore, the use of autograft may not provide adequate stability for the patella. Our group contained mostly idiopathic hypermobility patients with a smaller number of syndromic patients.

Allograft has been successfully used widely in the adult population,[14,19] but studies in children are limited. Hohn *et al*.[15] showed good early results using allograft in 25 pediatric and adolescent patients. In their study, 16% of patients developed postoperative complications, including one patella fracture, and 8% recurrent instability. The limitations of this study included its smaller patient numbers.

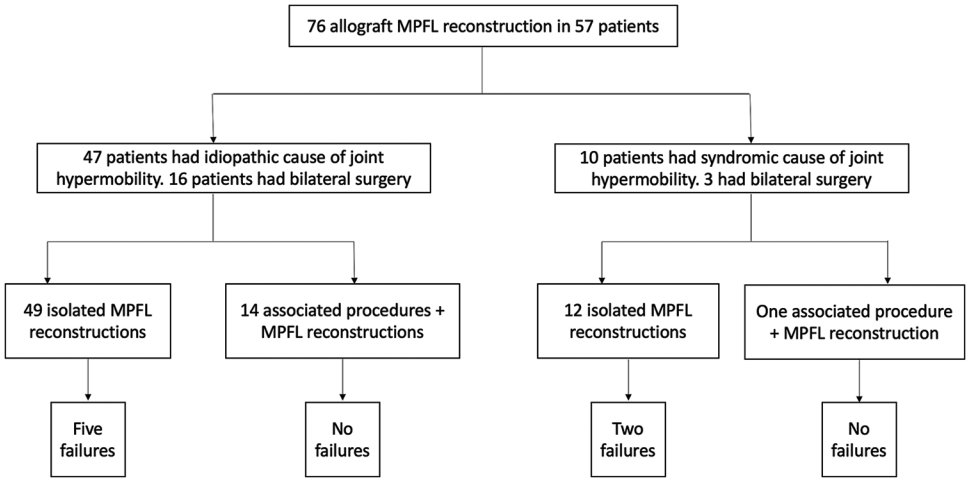

Figure 8: Summary of pathology and results

Howells *et al*.[21] compared the outcome of autograft MPFL reconstruction in 25 adults with hypermobility to a cohort of 50 patients without hypermobility. They showed significantly inferior Kujala score ($P < 0.001$) and patient satisfaction ($P = 0.011$) in patients with ligamentous hypermobility as compared to the control group. However, both groups improved significantly as compared to preoperative status. This shows the complexity of patients with hypermobility, which is a recognized risk factor for patellar dislocation. In their study, the postoperative Kujala score was 64.28, whereas, in our patients using an allograft for MPFL reconstruction, we achieved an average postoperative score of 89. The achievement of good functional scores in our cohort reinforces the advantages of using the allograft, which can preserve the native soft tissues, and it will be easy to rehabilitate these patients.

Our series is the largest in the literature with 76 procedures in 57 patients, and even after excluding the patients who had associated procedures, our final number consists of a 61 isolated allograft MPFL reconstruction procedures showing a success rate of 91% who had no further patellar instability at the latest follow-up. The complications seen in our study were comparable with those of other studies in literature, i.e., seven patients (9%) had a recurrence.

On further review of these cases, we noted that this was mainly due to shallow trochlear dysplasia (Dejour Type A) and possibly due to graft stretching due to femoral growth. In these patients with shallow trochlea, performing a trochleoplasty in the first instance is debatable because of the risk of growth plate injury. During the revision surgery, these patients had a trochleoplasty and had a successful outcome.

Added to this, as the child grows, the graft can stretch out and can become lax. We feel that allograft is a better choice in this group of patients who may have underlying collagen disorders. Also, by using allograft, the patient's native tissues are preserved and easy to rehabilitate. All the patients and their parents were counseled that MPFL reconstruction will help to regain their function to enable them to go back to regular activities. However, as the child grows, they may need further reconstruction if the existing reconstruction stretches out.

Two patients who had postoperative patellar fracture were successfully treated with tension band wiring, and the graft was salvageable. This is a recognized complication in other studies as well, and patients should be fully informed about this risk preoperatively.

Limitations of our study include firstly, some patients had additional procedures to MPFL reconstruction. These additional procedures comprise only 12 procedures and are 15% of the whole study group. Hence, we excluded these patients with additional procedures while analyzing our primary outcome measure of Kujala score. The additional procedures were only carried out in patients who had physeal closure and had bony structural problems. Secondly, both idiopathic and syndromic patients with hypermobility were included. However, we divided the patients into two separate groups, and outcome scores and redislocations were analyzed separately for each group to know how each of them was performed. This also shows that MPFL reconstruction can be considered in syndromic patients after the full child and parental education and informed consent process. Thirdly, we did not have preoperative scores. However, these children were only operated on after they had exhausted all nonoperative measures and were still suffering from patellar instability. The Kujala score was collected only at 1-year postoperative follow-up and so do not have a trend of improvement of the score over the first 1-year follow-up. We also do not routinely use radiographs to locate the femoral insertion point of MPFL. We did not observe any growth plate injuries in our patients.

Our study had a follow-up of an average of 3 years, and long-term studies are needed to look at the viability of the reconstruction as the child skeletally matures. Further

reconstruction may be required if the existing reconstruction stretches out. We plan to report our long-term outcomes of these children in future.

Conclusion

This is the first study reporting good short to mid-term functional outcomes with allograft MPFL reconstruction in children and adolescents with hypermobility. We recommend addressing the coexisting bony structural problems of patella-femoral joint if the growth plate is closed at the time of MPFL reconstruction. In our series, out of the 76 allograft MPFL reconstructions, 15 of those (20%) needed additional procedures to correct the structural abnormalities. These additional procedures were only carried out because these patients achieved skeletal maturity. Treating with isolated MPFL reconstruction in the presence of structural abnormalities in skeletally immature patients is debatable and it is advised to delay the surgery till child achieves skeletal maturity but need to look at a case-by-case basis to assess the benefits and morbidity.

Our study demonstrated that the use of allograft is safe and has the additional advantages of retaining children's native tissues, thus facilitating rehabilitation.

Ethical clearance

Local hospital clearance given to perform the study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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