Clinical Trial/Experimental Study

Medicine®

OPEN

Medial patellofemoral ligament reconstruction in children

A comparative randomized short-term study of fascia lata allograft and gracilis tendon autograft reconstruction

Łukasz Matuszewski, MD, PhD[a,*], Marek Tramś, MD, PhD[b], Andrzej Ciszewski, MD[a], Michał Wilczyński, MD[a], Ewa Tramś, MD[b], Paweł Jakubowski, MD[a], Anna Matuszewska, PhD[c], Kishore John, BS[a]

Abstract

Background: Many surgical procedures have been described to treat recurrent patellar dislocation, but none of these techniques has been successful in all patients. The goal of the study was to evaluate the results of medial patellofemoral ligament reconstruction in children. Two operative procedures were evaluated; a fascia lata allograft and an autologous gracilis graft.

Methods: Forty-four children (27 girls and 17 boys) between 13 and 17 years of age with unilateral recurrent patellar dislocation underwent medial patellofemoral ligament (MPFL) reconstruction. Patients were operated in two orthopedic centers. The 1st group contained 22 patients and surgery was performed using a fascia lata allograft. In the 2nd group of patients which also contained 22 children and autologous gracilis graft was used. The mean age of the patients was 14.9 years and the mean follow-up was 24 months. Preoperatively, all patients were evaluated clinically (Kujala score questionnaire) and radiologically. The same evaluation was used 18 to 30 months postoperatively to estimate the results of our treatment.

Results: In 1st group of children operated with cadaver allografts, the Kujala score significantly improved from 73.91 points preoperatively to 94.50 points postoperatively ($P < .001$). The average duration of operating procedure was 1 hour and 35 minutes. As shown by subjective symptoms, the results in 95% of patients were rated as good or very good. All children returned to full activity. Similar results were obtained in patients in 2nd group, where MPFL was reconstructed with ipsilateral gracilis tendon. Kujala score increased from 70.77 points preoperatively to 94.32 postoperatively ($P < .001$). Our results were estimated as good or very good in 93% of patients. All patients that were operated returned to full activity. However, median duration of operation was longer and lasted 1 hour and 55 minutes.

Conclusions: Both techniques were effective in the short-term (18–30 months) in treatment of recurrent patellar dislocation. The use of cadaver allograft spares the hamstring muscles and reduces the time of surgery. Therefore, such study appears to be useful because it provides valuable information that would help to guide treatment of this condition in children. Level of evidence II-2

Abbreviations: MPFL = medial patellofemoral ligament, ROM = range of motion, TT–TG = trochlear groove distance, VMO = vast us medialis oblique.

Keywords: medial patellofemoral ligament surgery, pediatric orthopedic, knee

Editor: Danny Chu.

MT and ET have contributed equally to this work.

It's guaranteed that none of the material in the manuscript has been published previously in any form and none of the material is currently under consideration for publication elsewhere other than noted in the covering letter to the Editor-in-Chief.

Each author has contributed substantially to the submitted work and has reviewed and agrees with the submission of the manuscript for review.

No funding was received for the work.

All authors have made a significant contribution to the findings and methods in the paper.

All authors have read and approved the final draft.

The study was approved by the institutional Ethics Committees: Bioethical Commission of Medical University in Lublin Al. Racławickie 1, 20-059 Lublin.

A consent to publish individual patients data were obtained from the participants (or legal parent or guardian for children). The datasets used and analyzed during the current study are available from the corresponding author upon a reasonable request.

None of the authors have any competing interests. There is no financial or commercial interest.

[a] Pediatric Orthopedics and Rehabilitation Clinic, Medical University of Lublin, [b] The Center of Sports Medicin Warsaw, Warsaw, [c] Biochemistry Department Maria Curie-Skłodowska University, Lublin, Poland.

[*] Correspondence: Łukasz Matuszewski, Pediatric Orthopedics and Rehabilitation Clinic, Medical University of Lublin, Poland (e-mail: lukasz.matuszewski@am.lublin.pl).

Medicine (2018) 97:50(e13605)

Received: 13 November 2017 / Accepted: 17 November 2018

http://dx.doi.org/10.1097/MD.0000000000013605

1. Introduction

The medial patellofemoral ligament (MPFL) plays a relevant role in maintaining proper mechanical stability of the patello-femoral joint. It is a thin structure within layer 2 of the medial knee soft tissues. It is closely attached to the undersurface of the vastus medialis oblique (VMO), a part of the quadriceps muscle. MPFL is the primary passive stabilizer preventing lateral displacement of the patella.[1] Complete patellar dislocation is always accompanied by MPFL injury. The spectrum of the injury ranges from elongation to complete rupture of the ligament that occurs usually at the femoral attachment. MPFL reconstruction is a very popular method used nowadays, especially for treatment of recurrent patellar dislocation.[2]

There are many predisposing factors of recurrent patellar dislocation. These include extensive knee valgus, obesity, trochlear dysplasia, patella alta, ligament hyperlaxity, or tibial torsion.[3,4]

Annual incidence of recurrent patella dislocation is around 6 per 100,000 in the general population. However, it is most common in adolescents, aged 10 to 17 of either sex.[5] The dislocation is usually caused by a twisting injury of the knee or a direct blow to the medial aspect of the patella, when the knee is in slight flexion, that usually occurs during sports activities. An associated osteochondral fracture of the patella or the lateral condyle of the femur may also occur. Hemarthrosis is frequently associated to this injury. The dislocation may reduce spontaneously. Management of a first-time traumatic dislocation is usually nonoperative. After initial post traumatic pain and swelling has subsided, the treatment focuses on concentric exercises to strengthen the vastus medialis muscle, as prevention of further instability. After a second dislocation, recurrent dislocations become more likely (49%) and surgery may be needed. Randomized controlled studies show that MPFL reconstruction in patients with recurrent patellar dislocation leads to good outcomes with low redislocation and complication rates.[6–8]

2. Purpose of the study

The objective of the study was to evaluate the treatment's parameters of medial patellofemoral ligament reconstruction in children, using 2 different graft sources. Those parameters were postoperative Kujala score in points or post- and preoperative difference in Kujala score; postoperative tilt angle in degrees or post-to preoperative difference in tilt angle; or operative time. Population of our patients consists of children with recurrent traumatic lateral patellar dislocation, with imaging-confirmed MPFL lesion and without associated lesions of other ligaments or cartilage. Though each described method is well documented in the literature, the significance of the paper is that it compares the results of these methods used in patients randomly selected within the same age group and only with unilateral dislocation of patella. Such comparative study in children is unavailable in the literature.

3. Methods

3.1. Study location and patients

This study was undertaken at 2 Polish hospitals between May 11, 2014 and May 5, 2015. All patients that were admitted to the Departments of Pediatrics Orthopedics with a diagnosis of patella dislocation were eligible for this research.

3.2. Study design and data collection

The goal of the study was to evaluate the results of 2 operative procedures of medial patellofemoral ligament reconstruction in children.

We hypothesized that both methods end with similar effective results.

Eligibility criteria included minimum second-time or recurrent patellar dislocation and MPFL insufficiency or rupture in ultrasound examination. Exclusion criteria included bilateral patella dislocation or other accompanying knee injuries such as anterior cruciate ligament (ACL), medial collateral ligament, lateral collateral ligament rupture, medial meniscus, or lateral meniscus lesion. In both orthopedics centers all patients underwent the same pre- and postoperative diagnostic procedures (ultrasound, x-rays, and magnetic rezonans imaging (MRI)) that were performed by the same radiologist.

Randomization was performed by authors of the article not included with surgical procedures. Patients always accepted method of treatment.

Surgical technique: In the Group 1, all children were operated using the same technique and by the same surgeon. Allografts were acquired from the Tissue Bank in Katowice, Poland. An 8 to 12 mm wide, 2 mm thick, and 5 to 7 cm long strip from the aponeurosis of the tensor fasciae lata muscle was prepared (Fig. 1). The ends of the graft were prepared with non-absorbable suture by the use of a baseball-suture technique.

Arthroscopy was performed in each case if any intraarticular pathology was found on the MRI. In Group 1 there was 1 patient with a medial meniscus tear that was treated with all-inside suture arthroscopic repair. In 3 patients, grade II cartilage damage according to Outerbridge was found and treated by microfractures. Patients with higher scores of cartilage damage were not included in our study. Following the arthroscopy, a 1.5 to 2 cm incision was made over the medial aspect of the patella and

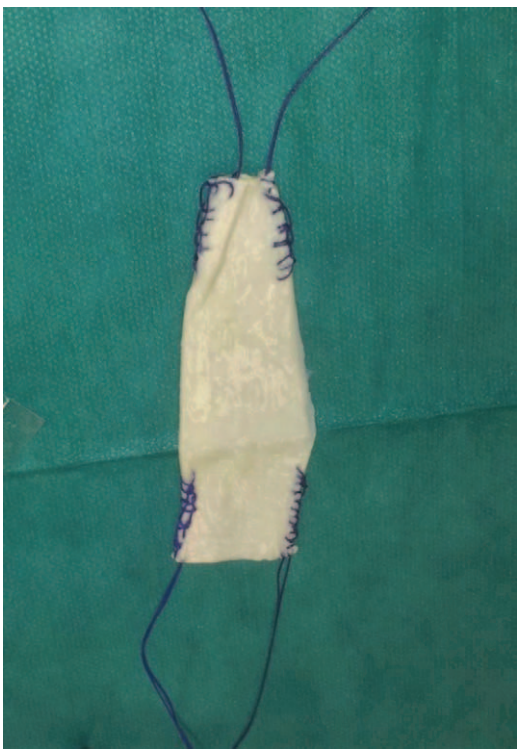


Figure 1. Allograft harvested from musculus tensor fascia lata.

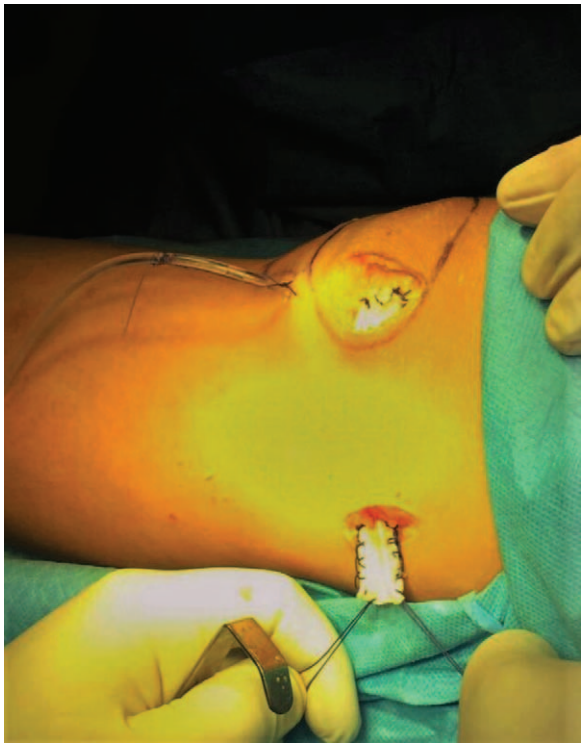


Figure 2. Allograft placement.

periosteum where the bone was exposed. Two oblique canals with the dimensions of 2 mm in diameter and 1 cm long were drilled in the upper and middle-medial third portions of the patella. Allograft was attached with sutures that were passed through those canals. A second incision, about 3-cm long, extended from the adductor magnus tendon to the medial epicondyle. Then a canal in subcutaneous tissue was created by blunt dissection between the medial aspect of patella and the femoral condylar incision (Fig. 2). Proper femoral insertion of the MPFL was identified under fluoroscopic control. Femoral attachment was localized 2 mm anterior and 4 mm distal to adductor tubercle, always below growth plate level (Fig. 3). The

Figure 3. Anchor placement.

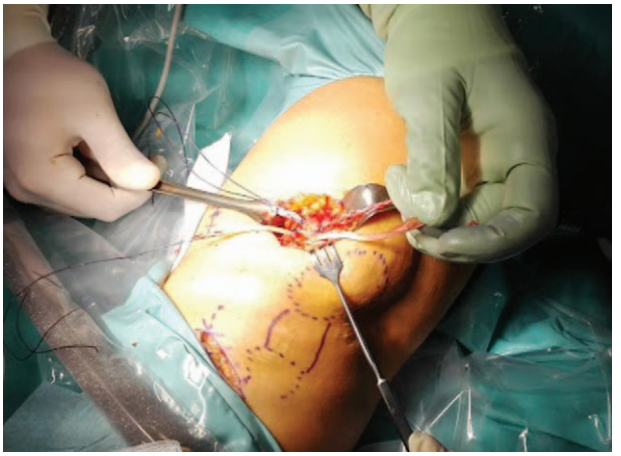


Figure 4. Autologus graft harvested from musculus gracilis.

femoral end of the graft was fixed with titanium anchor (Smith & Nephew, Warsaw, Poland) and proper tension was achieved in 20° of knee flexion. Patellar tracking was assessed in full range of motion. The wound was closed in layers. Drainage was used and compression dressing was applied.

In Group 2, the operations were performed by the same surgeon. If necessary, MPFL reconstruction was preceded by arthroscopy. In this group, 3 patients with grade II cartilage damage according to Outerbridge was found, which were treated by microfractures. This time, gracilis tendon was harvested from ipsilateral extremity, and used as MPFL graft. The tendon was cleared and prepared for grafting using standard techniques, resulting in 5 mm thick and 8 to 10 cm long V-shape graft (Fig. 4). Two canals 3 mm diameter each were drilled in the medial aspect of patella in the upper and middle-third parts of the patella. Then the graft was passed through those canals and fixed with non-absorbable sutures to the periosteum. Femoral insertion of the MPFL was identified and localized as described previously. End of the graft was passed subcutaneously beneath the fascia.

Figure 5. Femoral insertion of the MPFL. MPFL = medial patellofemoral ligament.

Position of the graft was always below growth plate level and fixed with the Milagro interference screw (Johnson & Johnson, Warsaw, Poland) in 20° to 30° of knee flexion (Fig. 5). Before completing the procedure, the patellar tracking and stability was assessed clinically in full range of motion of the knee. Finally, all the incisions were closed and drainage with compression dressing was used.

Rehabilitation: Specific integrated postoperative rehabilitation protocol was employed in all 44 patients. The knee was supported with a long leg knee brace for 3 weeks. Partial weight bearing was started on day 1 and continued up to 3 weeks. Knee range of motion (ROM) between 0° and 30° was started on the 2nd postoperative day together with electric stimulation of the vastus medialis muscle and mobilization of patella. The Knee ROM from 0° to 60° was started from the 2nd postoperative week. At the end of 3 weeks brace was removed, knee ROM between 0° and 90° and full weight bearing was allowed with sensorimotor education exercises. Patients started full pre-injury activities after 3 to 4 months postsurgery.

3.3. Statistical analyses

To evaluate the normality of data distribution Shapiro-Wilk test was used (Table 1). Statistical analysis was performed with *t* test and Mann–Whitney *U* test for comparison between the 2 groups. A Wilcoxon signed rank test and *t* test were used to assess change in the Kujala score and patellar tilt angle preoperatively and postoperatively. All statistical calculations were performed using 10.0 STATISTICA software (StatSoft, Poland) by Anna Matuszewska.

IRB "Ethical approval for this study was provided by the Ethical Committee of Medical University of Lublin on 27.03.2014."

4. Results

Forty-seven patients were enrolled to this study. Forty-four children were randomized. Patients with recurrent unilateral patellar dislocation underwent MPFL reconstruction were between 13 and 17 years of age. Surgery and research were performed with the local ethics committee approval. The participants were informed about the goal of the study and their parents signed consent agreements before the beginning of the study. The patients were split into 2 groups; age, sex were not taken into consideration for the breakdown of the groups in order to obtain complete randomisation (Table 1). In the 1st group of 22 patients, that contained, 10 boys and 12 girls, surgery was performed using cadaver fascia lata allografts. For the 2nd group of 22 children contained that contained 7 boys and 15 girls, ipsilateral gracilis tendon autografts were used (Table 2). Only unilateral dislocations of patella were included at both groups. Examinations of each group were performed in 2 different medical facilities.

Group 1 contains 12 right sided, 10 left sided dislocations; Group 2 contains 11 right sided, 11 left sided dislocations. The mean age of the patients was 14.97 years and the mean follow-up was 24 months. There were no statistically significant differences between groups regarding sex, side of operation, age at surgery time, and duration of the complaints. All patients were evaluated clinically and radiologically. In all patients tibial tuberosity–trochlear groove distance (TT–TG) preoperatively was <20 mm, as assessed in preoperative magnetic resonance scans. Merchant view radiographs in 30° flexion were performed preoperatively to assess the tilt angle. The tilt angle was defined as the angle subtended by a line joining the medial and lateral edges of the patella and the horizontal. There were no statistically significant differences in the tilt angle between the 2 groups. All patients had dynamic ultrasound examination performed that showed evidence of MPFL insufficiency or rupture. Preoperatively magnetic resonance imaging was done in patients to confirm intra-articular pathologies. Kujala score questionnaire was used preoperatively and 18 to 30 months postoperatively to evaluate the results of the treatment.[9]

All patients underwent dynamic ultrasound examination on the final follow up, which showed good tension of the MPFL graft in all cases, and correct tracking of the patella.

In Group 1 the patellar tilt angle, assessed in postoperative radiographs in Merchant view, improved significantly from 21.3° ±2.8° before surgery to 9.4° ±1.5° at the last follow-up. Those changes were statistically significant ($P < .001$ in *t* test and Wilcoxon test) (Tables 3 and 4). The Kujala score significantly improved from 73.91 ± 7.84 points preoperatively to 94.5 ± 3.90 points postoperatively. This improvement was statistically significant ($P < .001$ in *t* test and Wilcoxon test) (Tables 3 and 5). According to the subjective symptoms, obtained results in 95% of patients were rated as good or very good. All children returned to full activity, including sports such as skiing, basketball, football, or dancing. Median duration of operation was 1 hour and 35 minutes.

In Group 2 the patellar tilt angle had also significant improvement from 20.9° ± 3.1° before surgery to 10.4° ± 1.7° at the last follow-up (Tables 3 and 4). The Kujala score

Table 1

Data distribution.

	Group I			Group II		
Data	**S-W test**	**df**	***P***	**S-W test**	**df**	***P***
Age	0.928	22	.111	0.832	22	.002**
Amount of patella dislocations	0.929	22	.117	0.852	22	.004**
TT–TG, mm	0.926	22	.101	0.890	22	.019*
Preoperative Kujala score	0.892	22	.021*	0.985	22	.973
Postoperative Kujala score	0.940	22	.196	0.917	22	.064
Preoperative patellar tilt	0.943	22	.227	0.937	22	.168
Postoperative patellar tilt	0.925	22	.098	0.926	22	.100
Kujala score, pre- and postoperative difference	0.971	22	.200	0.971	22	.734
Patellar tilt, pre- and postoperative difference	0.940	22	.047*	0.940	22	.202

* $P < .05$, $P > .01$ the data are not normally distributed.
** $P < .01$ the data are not normally distributed (highly).

Table 2

Statistical and demographic analysis of Group 1 and Group.

Sex	Group					
	No.1		No.2		Total	
	N	%	N	%	N	%
Female	12	54.,5%	15	68.2%	27	61.4%
Male	10	45.5%	7	31.8%	17	38.6%
Total	22	100.0%	22	100.0%	44	100.0%

	Group					
	No.1		No.2		Total	
Side	N	%	N	%	N	%
Right	12	54.5%	11	50.0%	23	52.3%
Left	10	45.5%	11	50.0%	21	47.7%
Total	22	100.0%	22	100.0%	44	100.0%

							Test *t* student/Mann–Whitney *U* test	
	Group	Min	Max	*M*	Me	SD	*t*/*Z*	*P*
Age at the time of surgery	No.1	13	17	15.00	15.0	1.11	*Z*=−0.012	.990
	No.2	13	16	14.95	15.0	1.05		
Amount of patella dislocations	No.1	2	8	4.77	5.0	1.88	Z=−1.248	.212
	No.2	2	10	4.18	3.5	2.28		
TT–TG, mm	No.1	12	18	14.86	15.0	1.98	Z=−0.474	.635
	No.2	11	18	15.09	16.0	2.47		
Kujala before surgery	No.1	55	86	73.91	76.0	7.84	*t*=1.136	.262
	No.2	48	90	70.77	72.0	10.30		
Kujala after surgery	No.1	88	100	94.50	94.0	3.90	*t*=0.143	.887
	No.2	87	100	94,32	94,5	4,51		
Patellar tilt before surgery	No.1	16	26	21.27	21.5	2.80	*t*=0.462	.647
	No.2	16	26	20.86	21.0	3.08		
Patellar tilt after surgery	No.1	7	12	9.45	10.0	1.47	*t*=−2.004	.051
	No.2	7	13	10.41	10.0	1.68		

Statistical analysis of Group 1 and Group 2.

significantly improved from 70.77±10.30 points preoperatively to 94.32±4.51 points postoperatively ($P<.001$ in *t* test and Wilcoxon test) (Tables 3 and 5). Outcome in 93% of patients were rated as good or very good. No statistically significant differences were found in the values of the tilt angle or Kujala scored when comparing end results between groups with *t* test and Mann–Whitney *U* test (Table 2). Median duration of operation was 1 hour and 55 minutes.

There were no serious complications in patients where the gracilis tendon autografts were used. There was one unilateral redislocation in Group 1, after a traumatic event half a month after surgery. During revision surgery, it was found that the femoral anchor migrated from the bone. One patient had a wound infection in the region of the femoral attachment of the allograft. It was treated with oral antibiotics.

5. Discussion

Our study shows that to use of cadaver allograft spares the hamstring muscles and reduces the time of surgery. There are many surgical procedures described to treat recurrent patellar dislocation, but none of these techniques proved to be successful in all patient groups. Different types of grafts used for ligament reconstruction described in literature result in high success rates.

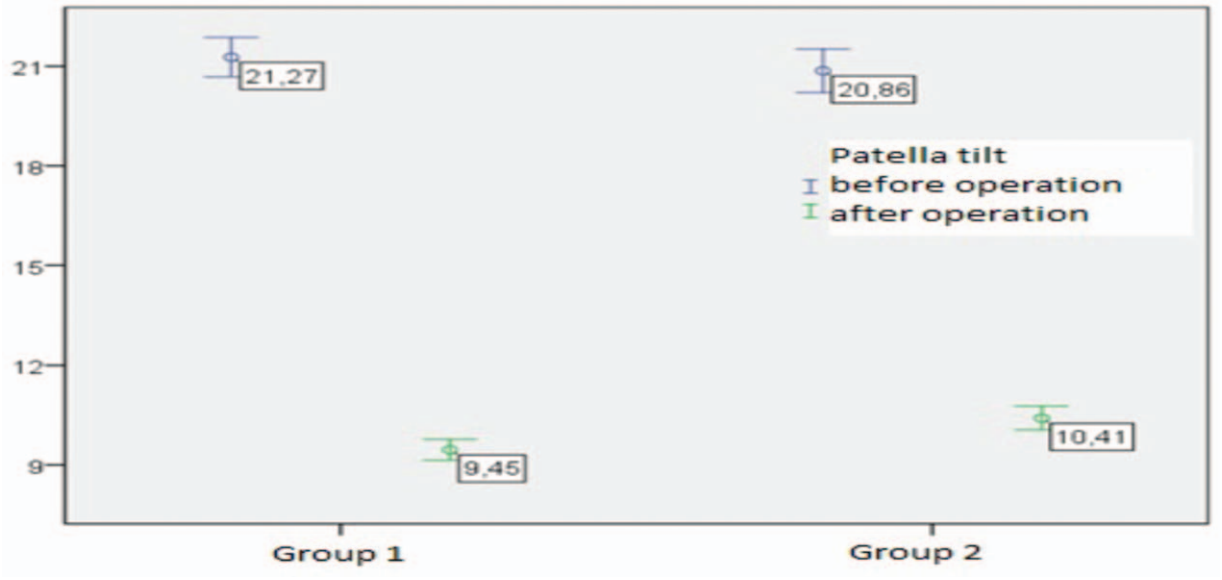
Table 3

Statistical analysis of Group 1 and Group 2—Kujala Score and patella tilt.

							t Test /Wilcoxon test
Group 1	Examination time	Min	Max	Av	Me	SD	*P*
Kujala score	Before operation	55	86	73.91	76.0	7.84	.001
	After operation	88	100	94.50	94.0	3.90	
Patella tilt	Before operation	16	26	21.27	21.5	2.80	.001
	After operation	7	12	9.45	10.0	1.47	
Group 2	Examination time	Min	Max	Av	Me	SD	
Kujala score	Before operation	48	90	70.77	72.0	10.30	.001
	After operation	87	100	94.32	94.5	4.51	
Patella tilt	Before operation	16	26	20.86	21.0	3.08	.001
	After operation	7	13	10.41	10.0	1.68	

Table 4

Statistical chart comparing changes of patella tilt in both groups.



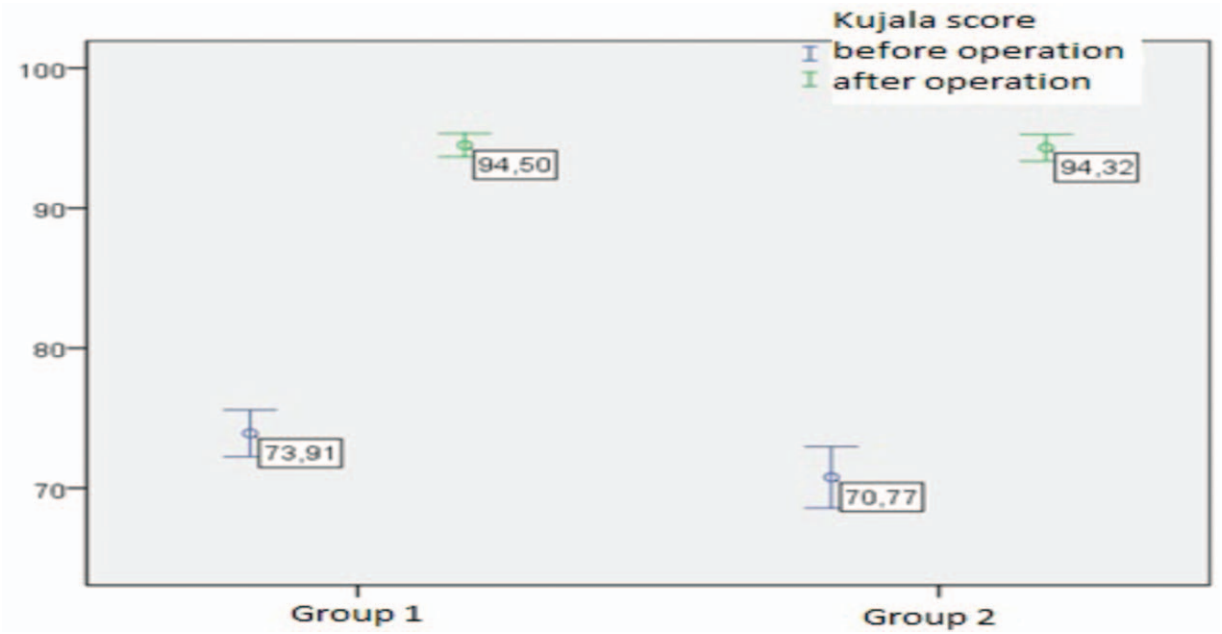
None of the grafting types and techniques proved to be undeniably superior to one another. They all produce similar success rates.[10–12] Therefore, further controlled prospective studies are needed to compare the outcomes of different methods of MPFL reconstruction in children.

Semitendinosus and gracilis tendons are the most popular graft sources and are commonly used for MPFL reconstructive in both adults and children.[13–15] Other graft sources include a part of the quadriceps tendon or a part of the tensor fasciae lata.[16,17]

Before modern MPFL reconstruction, many different techniques were performed in the 1990s. Proximal realignment procedures such as medial plication and lateral release have been used, however, with various recurrence rates. The medial transfer of tibial tuberosity was an isolated procedure that produced poor results.[18,19] In the early 1990s Conlan and Garth[20] identified the MPFL as the primary medial stabilizing structure. It was proved that about 53% of medial restraint is provided by MPFL. However, surgical exploration as well as radiological and

Table 5

Statistical chart comparing changes of Kujala Score in both groups.



biomechanical studies showed that MPFL is injured in most cases of patellar dislocation.[21] In consequence, MPFL reconstruction has become a widely accepted procedure for restoration of patellofemoral stability.

In this study we used an allograft from fascia lata in Group 1 and a gracilis tendon autograft in Group 2 for MPFL reconstruction. No significant healing problems were encountered in either group, apart from one case of mild superficial infection in fascia lata group. Postoperative ultrasound and clinical examination did not show any laxity or insufficiency of the graft. The single recurrent dislocation was due to loosening of the anchor in the bone; not graft material insufficiency or failure on the graft-implant interface. Since no significant differences in the final results of treatment were found between both groups, we believe that fascia lata allograft is a safe and reliable procedure. This procedure spares hamstring muscles that can be preserved for other possible future reconstruction procedures. Therefore, postoperative pain from donor site is avoided, and operative time is reduced.

Apart from various types of grafts, there are some differences in graft fixation methods. The main goal of treatment should be an anatomic reconstruction of the MPFL.[22] The most important factor in anatomic reconstruction of the MPFL in children is considered to be the proper location of the femoral attachment.

Sanchis-Alfonso[23] proved that proper identification of the adductor tubercle is the key to success. The femoral attachment of the MPFL is located distal to the apex of the adductor tubercle and parallel to the long axis of the femur. Nelitz supported the idea of anatomic reconstruction of the MPFL in children with open growth plates.[14] In this study, the femoral insertion of the graft was placed below growth plate to avoid damage to the distal femoral physis both group of patients. That distal location is a very important factor that prevents further redislocation of the femoral attachment of the reconstructed MPFL due to bone's growth.

Some authors emphasize the importance of the tension of reconstructed MPFL. Kiapour et al[24] determined average stiffness of MPFL to be 16 N/mm. Proper tension of the graft is very important because excessive tension may result in medial impingement and further patellofemoral arthrosis in a long-term follow-up.[25] In this study no device to measure tension of the graft was used. The knee was flexed several times to obtain optimal tension of the allograft. It allows to control proper alignment of the patella in the trochlear groove and tension of the allograft. This method consistent with the literature.[26,27]

The principles of rehabilitation after MPFL reconstruction are similar to those used after other ligamentous reconstructions of the knee.[28]

The rehabilitation protocol should be followed rigorously. It consists mainly of early passive mobilization of the patella with pain control, adjustment of proper range of motion and quadriceps strengthening. The use sensorimotor education exercises as an essential component of rehabilitation protocol is advocated.[29] It helps to regain proper motor activation and control of the dynamic restraints of the knee, improving functional joint stability, and lower limb neuromuscular control.

Nowadays, the reconstruction of the MPFL in recurrent patellar dislocation treatment in children has become a popular and very efficient procedure, particularly in patients who have had a long history of previous patellar dislocations. However, the choice of graft and surgical technique remains a subject of continued discussion.[30] Many reports show that technical intraoperative errors and inappropriate patient selection are the main factors that result in the need for revision surgery after MPFL reconstruction.[31] Proper patient selection and identification of associated pathology is mandatory for successful surgery.

In our study, that included 2 groups of patient with MPFL reconstruction with an allograft and autograft, we had only one redislocation and no other serious complication. The mean Kujala score of 94.5 points and 94.32 points for the first and second group respectively is comparable to other studies.[32]

In adults, there are a lot of techniques described for MPFL reconstruction, with different graft sources. Scientific reports evaluate the differences in survivorship, clinical outcomes, and cost. Such surgery usually results in good postoperative patellar stability with redislocation rates <4%.[33] This article presents 2 efficient techniques for MPFL reconstruction in patients with open physis. There are only few randomized comparison studies of different surgical techniques of MPFL reconstruction in this age group.[34–36] A recent biomechanical study shows that the type of graft material is of little importance when correct anatomic reconstruction is performed. In that particular study by Stephen et al authors claim that the correct femoral tunnel position and graft tension for restoring normal patellofemoral joint kinematics and articular cartilage contact stresses appear to be more important than graft selection during MPFL reconstruction.[37] We would like to add that the role of type of the graft was taken into consideration by Engelman et al[38] and Botoni et al,[39] in the study that focused on ACL reconstruction in children and adolescents. Based on this large retrospective cohort study, those authors recommend the use of autogenous grafts in children and adolescents undergoing primary, transphyseal ACL reconstruction. Same findings were reported by Keading et al.[40] In their study allograft graft type were predictors of increased odds of ipsilateral graft failure.

6. Conclusions

The results provided in this study show that fascia lata allograft is a reliable graft in MPFL reconstruction, and yields the same results of treatment as standard autograft procedures. Both techniques are effective in treatment of recurrent patellar dislocation. Therefore our study might be useful and provides valuable information that would help to guide treatment of this condition in children.

Acknowledgments

The authors would like to thank Dr Marek Zaluski (Montana, US) for his great support and help during preparation of manuscript.

Author contributions

Conceptualization: Łukasz Matuszewski, Ewa Tramś.
Data curation: Łukasz Matuszewski, Andrzej Ciszewski, Marek Tramś, Michal Wilczynski, Ewa Tramś.
Formal analysis: Łukasz Matuszewski, Andrzej Ciszewski, Michal Wilczynski, Anna Matuszewska.
Methodology: Marek Tramś, Ewa Tramś.
Project administration: Ewa Tramś, Paweł Jakubowski.
Resources: Ewa Tramś.
Supervision: Paweł Jakubowski.
Validation: Łukasz Matuszewski, Paweł Jakubowski.
Visualization: Łukasz Matuszewski, Paweł Jakubowski.

Writing – original draft: Łukasz Matuszewski, Paweł Jakubowski, Kishore John, Anna Matuszewska.
Writing – review & editing: Łukasz Matuszewski, Paweł Jakubowski, Kishore John, Anna Matuszewska.

References

[1] LaPrade RF, Engebretsen AH, Ly TV, et al. The anatomy of the medial part of the knee. J Bone Joint Surg Am 2007;89:2000–10.
[2] Witonski D, Keska R, Synder M, et al. An isolated medial patellofemoral ligament reconstruction with patellar tendon autograft. Biomed Res Int 2013;2013:637678.
[3] Steiner TM, Torga-Spak R, Teitge RA. Medial patellofemoral ligament reconstruction in patients with lateral patellar instability and trochlear dysplasia. Am J Sports Med 2006;34:1254–61.
[4] Bollier M, Fulkerson J. The role of trochlear dysplasia in patellofemoral instability. J Am Acad Orthop Surg 2011;19:8–16.
[5] Howells NR, Barnett A, Ahearn N, et al. Medial patellofemoral ligament reconstruction: a prospective outcome assessment of a large single centre series. J Bone Joint Surg 2012;94:1202–8.
[6] Nikku R, Nietosvaara Y, Aalto K, et al. Operative treatment of primary patellar dislocation does not improve medium term outcome. Acta Orthop 2005;76:699–704.
[7] Fisher B, Nyland J, Brand E, et al. Medial patellofemoral ligament reconstruction for recurrent patellar dislocation: a systematic review including rehabilitation and return-to-sports efficacy. Arthroscopy 2010;26:1384–94.
[8] Muderis A, Stein MS, Krimly A, et al. Minimally invasive surgical technique in treating recurrent patellar dislocation. J Sci Med 2012; 15:132–3.
[9] Kujala UM, Jaakkola LH, Koskinen SK, et al. Scoring of patellofemoral disorders. Arthroscopy 1993;9:159–63.
[10] Lenschow S, Schliemann B, Gestring J, et al. Official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2013; Medial patellofemoral ligament reconstruction: fixation strength of 5 different techniques for graft fixation at the patella. J Arthrosc Relat Surg 2013;29:766–73.
[11] Ahmad CS, Brown GD, Stein BS. The docking technique for medial patella femoral ligament reconstruction: surgical technique and clinical outcome. Am J Sports Med 2009;37:2021–7.
[12] Deie M, Ochi M, Sumen Y, et al. Reconstruction of the medial patellofemoral ligament for the treatment of habitual or recurrent dislocation of the patella in children. J Bone Joint Surg Br 2003;85: 887–90.
[13] Gausden EB, Fabricant PD, Taylor SA, et al. Medial patellofemoral ligament reconstruction in children and adolescents. JBJS Rev 2015;3:e2.
[14] Nelitz M, Dreyhaupt J, Reichel H, et al. Anatomical reconstruction of the medial patellofemoral ligament in children and adolescents with open growth-plates: surgical technique and clinical outcome. Am J Sports Med 2013;41:58–63.
[15] Ostermeier S, Stukenborg-Colsman C, Wirth CJ, et al. Reconstruction of the medial patellofemoral ligament by tunnel transfer of the semitendinosus tendon. Oper Orthop Traumatol 2007;19:489–501.
[16] Vavalle G, Capozzi M, Nelitz M, et al. Isolated reconstruction of the medial patellofemoral ligament with autologous quadriceps tendon. J Orthop Traumatol 2016;17:155–62.
[17] Nelitz M, Williams SR. Anatomic reconstruction of the medial patellofemoral ligament in children and adolescents using a pedicled quadriceps tendon graft. Arthrosc Tech 2014;3:e303–8.
[18] Scuderi G, Cuomo F, Scott WN. Lateral release and proximal realignment for patellar subluxation and dislocation. A long term followup. J Bone Joint Surg Am 1988;70:856–61.
[19] Zeichen J, Lobenhoffer P, Gerich T, et al. Medium-term results of the operative treatment of recurrent patellar dislocation by Insall proximal realignment. Knee Surg Sports Traumatol Arthrosc 1999;7:173–6.
[20] Conlan T, Garth WPJr, Lemons JE. Evaluation of the medial soft-tissue restraints of the extensor mechanism of the knee. J Bone Joint Surg Am 1993;75:682–93.
[21] Steensen RN, Dopirak RM, McDonald WGIII. The anatomy and isometry of the medial patellofemoral ligament: implications for reconstruction. Am J Sports Med 2004;32:1509–13.
[22] Schottle PB, Schmeling A, Rosenstiel N, et al. Radiographic landmarks for femoral tunnel placement in medial patellofemoral ligament reconstruction. Am J Sports Med 2007;35:801–4.
[23] Sanchis-Alfonso V. Guidelines for medial patellofemoral ligament reconstruction in chronic lateral patellar instability. J Am Acad Orthop Surg 2014;22:175–82.
[24] Kiapour A, Kiapour AM, Kaul V, et al. Finite element model of the knee for investigation of injury mechanisms: development and validation. J Biomech Eng 2014;136:011002.
[25] Nomura E, Inoue M, Kobayashi S. Long term follow-up and knee osteoarthritis change after medial patellofemoral ligament reconstruction for recurrent patellar dislocation. Am J Sports Med 2007;35:1851–8.
[26] Chotel F, Peltier A, Viste A, et al. Physeal-sparing MPFL reconstruction in children La Patella, 15e journées Lyonnaises de chirurgie du genou, SaurampsMédical. Montpellier 2012;47–52.
[27] Chotel F, Bérard J, Raux S. Patellar instability in children and adolescents. Orthop Traumatol Surg Res 2014;100(suppl):S125–37.
[28] Fithian DC, Powers CM, Khan N. Rehabilitation of the knee after medial patellofemoral ligament reconstruction. Clin Sports Med 2010;229: 283–90.
[29] Riemann BL, Lephart SM. The sensorimotor system, Part II: the role of proprioception in motor control and functional joint stability. J Athl Train 2002;37:80–4.
[30] Matthew JJ, Peter S. Reconstruction of the medial patellofemoral ligament using a longitudinal patellar tunnel technique. Int Orthop 2010;34:1321–5.
[31] Nelitz M, Williams RS, Lippacher S, et al. Analysis of failure and clinical outcome after unsuccessful medial patellofemoral ligament reconstruction in young patients. Int Orthop 2014;38:2265–72.
[32] Deie M, Ochi M, Sumen Y, et al. A long-term follow-up study after medial patellofemoral ligament reconstruction using the transferre semitendinosus tendon for patellar dislocation. Knee Surg Sports Traumatol Arthrosc 2005;13:522–8.
[33] Arendt EA, Lind M, van der Merwe W. Indications for MPFL reconstruction after patellar dislocation. ISAKOS Newsl 2009;13:29–31.
[34] Palmu S, Kallio P, Donell S. Acute patellar dislocation in children and adolescents: a randomized clinical trial. J Bone Joint Surg Am 2008; 90:463–70.
[35] Schneider DK, Grawe B, Magnussen RA, et al. Outcomes after isolated medial patellofemoral ligament reconstruction for the treatment of recurrent lateral patellar dislocations: a systematic review and meta-analysis. Am J Sports Med 2016;44:2993–3005.
[36] Hinckel BB, Gobbi RG, Bonadio MB, et al. Reconstruction of medial patellofemoral ligament using quadriceps tendon combined with reconstruction of medial patellotibial ligament using patellar tendon: initial experience. Rev Bras Ortop 2016;51:75–82.
[37] Stephen JM, Kittl C, Williams A, et al. Effect of medial patellofemoral ligament reconstruction method on patellofemoral contact pressures and kinematics. Am J Sports Med 2016;44:1186–94.
[38] Engelman GH, Carry PM, Hitt KG, et al. Comparison of allograft versus autograft anterior cruciate ligament reconstruction graft survival in an active adolescent cohort. Am J Sports Med 2014;42:2311–8.
[39] Bottoni CR, Smith EL, Shaha J, et al. Autograft versus allograft anterior cruciate ligament reconstruction: a prospective, randomized clinical study with a minimum 10-year follow-up. Am J Sports Med 2015; 43:2501–9.
[40] Kaeding CC, Pedroza AD, Reinke EK, et al. Risk factors and predictors of subsequent ACL injury in either knee after ACL reconstruction: prospective analysis of 2488 primary ACL reconstructions from the MOON cohort. Am J Sports Med 2015;43:1583–90.