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Clinical outcome after medial patellofemoral ligament reconstruction and autologous chondrocyte implantation following recurrent patella dislocation

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Abstract
Purpose Medial patellofemoral ligament (MPFL) reconstruction is a well-established treatment option in recurrent patella dislocation. The combination with associated retropatellar cartilage lesions are severe injuries and very difficult to treat. The purpose of this study was to evaluate our clinical results of MPFL reconstruction and autologous chondrocyte implantation (ACI).
Methods Thirteen patients with recurrent patella dislocation were treated with a combination of MPFL reconstruction and ACI at our institution between 2010 and 2014. All patients had at least 2 patella dislocations. The post-traumatic cartilage lesions were grade IV according to the ICRS and were localized retropatellar in 8 cases and at the lateral femoral condyle in 2 cases. The mean defect size was 7.2 ± 3.5 cm^2 (3–12 cm^2). Subjective and objective scores were assessed before surgery and at f/u, as well as radiologic parameters and cartilage status on magnetic resonance imaging (MRI).
Results Ten patients (5 male, 5 female) with a mean follow-up of 2 years (minimum 1 year to 4 years) were enrolled in the study. At latest clinical follow-up, all patients had a stable patella with no signs of instability and all patients showed improved subjective and objective scores. Lysholm score increased to 74.1 ± 18.7 (48–99), KOOS score to 74.4 ± 16.9 (57–95), IKDC subjective to 63.9 ± 22.1 (34–93) and Kujala score to 73.8 ± 25.1 (50–100). The post-operative modified MOCART score for quality assessment of the ACI on MRI was an average of 13.7 ± 1.8 points (11–16), with a complete fill of the defect in 80 % of lesions.
Conclusion Medial patellofemoral ligament reconstruction with simultaneous ACI showed good clinical results in recurrent patella dislocation with traumatic cartilage lesions grade IV. No patella re-dislocation occurred and the ACI was successful in 80 % of patients according to MRI. Subjective and objective scores improved but combined surgery is inferior to reports from the literature on MPFL reconstruction alone without cartilage damage.
Level of evidence Therapeutic case series, Level IV.

Keywords Recurrent patella dislocation · Cartilage lesion · MPFL reconstruction · ACI · Retropatellar

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Introduction

Disruption of the medial patellofemoral ligament (MPFL) is a common finding in recurrent patella dislocation. The MPFL is the most important soft tissue stabilizer and contributes 50–60 % to the medial constraints of the patella [4, 5, 8, 17, 24]. Subsequent dislocations are often associated with significant soft tissue damage [5, 8] and chronic instability often causes severe damage to the articular cartilage

of the patella, lateral femoral condyle and trochlea [4, 21, 30, 38]. In MRI studies, the prevalence for traumatic cartilage damage caused by patella dislocations was shown to be as high as 40–96 % [4, 30, 39]. Patellofemoral stability and alignment are the keys to prevent further traumatic damage to the chondral surfaces [20, 22], and MPFL reconstruction has proofed to be very effective in preventing re-dislocations in such case [5, 8, 15, 18, 23, 24].

Cartilage damage grade IV according to the ICRS [2] to the patellofemoral joint may cause significant pain and discomfort and should therefore be addressed, too. Especially retropatellar cartilage repair is very difficult to perform and marrow stimulating techniques were reported to be of limited success [33]. In contrast, clinical outcome studies of autologous chondrocyte implantation (ACI) at the knee were promising [1, 7, 10, 12, 19, 26]. Reports of combined patellofemoral ACI with patella stabilization are rare. The combination with distal bony realignment was shown to be successful [10, 36], but there are no reports of ACI with combined MPFL reconstruction.

This study introduces a new surgical technique of arthroscopic ACI at the patella combined with MPFL reconstruction. The minimal invasive approach reduces surgical trauma and allows for easy post-operative rehabilitation.

The aim of this study was to evaluate the clinical results of patients with recurrent patella dislocation and traumatic grade IV cartilage lesions which underwent arthroscopic ACI combined with MPFL reconstruction.

Materials and methods

One hundred and three MPFL reconstructions were performed for recurrent patellar dislocation at our centre between January 2010 and February 2014. Thirteen patients (12.6 %) were found to have a traumatic grade IV cartilage lesion according to the ICRS [2] caused by recurrent dislocations (Figs. 1a, b, 2a) and were treated with a combination of MPFL reconstruction and ACI 8 weeks later after autologous cartilage cell cultivation (Fig. 2b). All surgeries were performed by the first author. The mean age of the patients was 23 ± 9.8 years (19–31), and all patients had at least 2 patella dislocations. The cartilage lesions were localized retropatellar ($n = 11$) and on the lateral femoral condyle ($n = 2$). The median size of the cartilage lesion was 7.2 ± 3.5 cm^2 (3–12 cm^2). According to the Dejour classification for patellofemoral dysplasia, 9 patients had grade A dysplasia, 2 grade B and 2 grade C. Eight out of

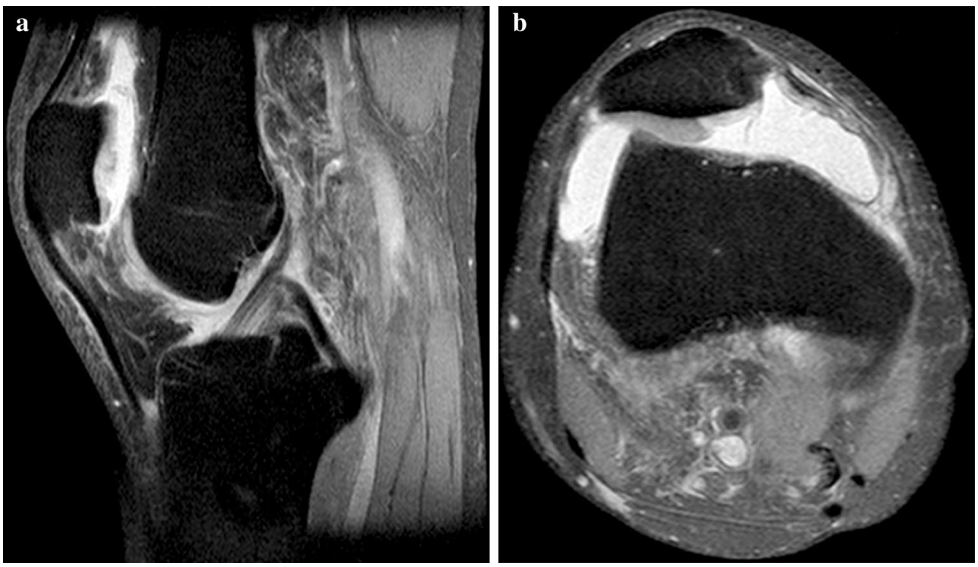

Fig. 1 Sagittal (**a**) and axial (**b**) MRI after patella dislocation: patellofemoral dysplasia, lateral subluxation, chronic MPFL rupture and traumatic retropatellar chondral damage grade IV according to ICRS. Joint effusion, bone bruise of patella

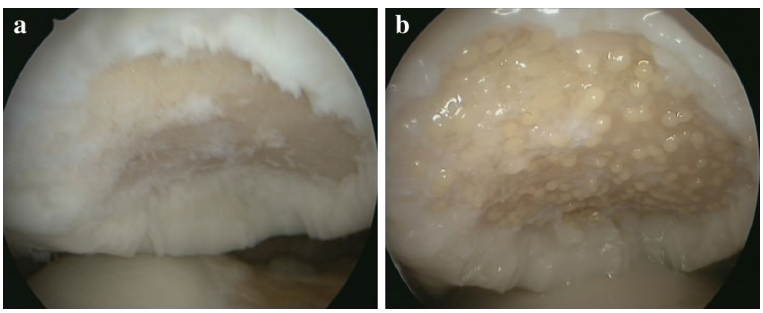

Fig. 2 Arthroscopic aspect of retropatellar chondral damage grade IV with surrounding intact cartilage shoulder of same patient (**a**). S/p arthroscopic ACI with autologous cartilage cells (spheroids) (Co.don) implanted in the retropatellar cartilage defect (**b**)

the 13 patients (61.5 %) had undergone one or more operations before in the affected knee for patella instability. Six of them underwent medial plication and/or lateral release, while the others only chondroplasty.

Indications for a MPFL reconstruction included patients that had a clear history of recurrent patella dislocation (Fig. 1a, b). Indications for ACI included posttraumatic cartilage lesions grade IV according to the ICRS classification, which occupied a surface area larger than 3 cm^2, surrounded by an intact cartilage shoulder (Fig. 2a). Each patient underwent a routine radiographic examination preoperatively and at follow-up including posteroanterior weight bearing in 45° of flexion (Rosenberg view), lateral view, as well as magnetic resonance imaging (MRI).

Surgical technique

MPFL reconstruction

A diagnostic arthroscopy was performed using standard parapatellar medial and lateral portals to reconfirm the patella instability, concomitant pathology and the indication for MPFL reconstruction and cartilage repair. The anatomical length of the intact MPFL is an average of 53 mm [5], and a gracilis tendon graft was prepared to approximately 20–22 cm. The two ends of the tendon graft were each sutured with No. 2 resorbable vicryl sutures using a whipstitch technique up to approximately 2 cm.

The femoral origin of the MPFL was palpated at the saddle between the adductor tubercle and the insertion of the medial collateral ligament (MCL) at the medial femoral epicondyle and reconfirmed by a lateral fluoroscopy [28]. A bone tunnel, usually 5 mm and 5–6 cm deep was established at the origin. At the insertion of the MPFL at the patella, two blind bone tunnels (2 cm deep, 3.2 mm diameter) were created 10 mm apart from each other to fixate both ends of the gracilis tendon graft with sutures. At the femoral origin, the graft was fixed with a 6 × 25 mm bioresorbable interference screw in 30° of flexion. The principles of above technique were described recently in detail [29].

ACI technique

Similar to most ACI techniques, the procedure required two surgical steps. The traumatic grade IV cartilage lesion [2] at the patella or the lateral femoral condyle was reconfirmed at time of MPFL reconstruction, and a cartilage biopsy was taken from a region of normal cartilage at the intercondylar notch. The autologous cartilage cells were cultivated for 8 weeks (Co.don AG, Teltow, Germany). Arthroscopic implantation of the 3-dimensional spheroids was then performed with the patient in supine position after cleaning of the defect and the subchondral bone plate. The cultivated cartilage cells were introduced into the joint by a dry-arthroscopy using a delivery syringe and were spread out evenly with a probe (Fig. 2a, b). The spheroids were allowed to set in place for 20 min to develop adhesions to the subchondral bone plate of the lesion before portal closure.

Rehabilitation

The principles for rehabilitation were early motion with partial weight bearing. Knee motion was started on the second post-operative day using a CPM machine and physiotherapy. Extension was unrestricted. Flexion was encouraged up to 60° for the first 2 post-operative weeks, to 90° for the 3rd post-operative week and unrestricted thereafter. Ten kilogram partial weight bearing on crutches was performed for 6 weeks and a brace was used during that time. Cycling, swimming (stroke) and aqua jogging was encouraged after 7–8 weeks, and full return to sports was restricted for 1–2 years, depending on the activity.

Clinical evaluation

All patients ($n = 10$) with a follow-up of 1 year or more were included in the study. Patients were examined 3 and 6 weeks, 3 and 6 months and yearly thereafter. Clinical improvement was assessed by physical examination, Lysholm score [34], Tegner score [34], Knee injury and Osteoarthritis Outcome Score (KOOS) [27], objective International Knee Documentation Committee (IKDC) [13] and Kujala score [16]. Physical examination included clinical testing of patella stability, presence or not of a positive apprehension, sign, position of tuberositas tibiae, leg axis, joint effusion, range of motion (ROM) and reproduction of pain after pressure at the involved and contralateral knee. ROM was measured with a goniometer, in comparison to the non-operated side. The study was performed according to the Medical Association Declaration of Helsinki.

Statistical analysis

For all statistical analysis, the paired sample t test was used. Median and range (min–max) were calculated for cartilage defect size. Due to the normal distribution of all morphometric variables ($p > 0.05$) in this study, median, standard deviation (SD) and range (min–max) were calculated for all outcomes. As all available patients were included consecutively, no a priori sample size calculation was conducted. Instead post hoc power analyses were done with the "Power And Sample Size program" (available at http://powerandsamplesize.com/) as described by Chow et al. [40]. All other analyses were

calculated with SPSS 21 Statistics (IBM Corporation, Armonk, USA).

Objective evaluation

Radiographic assessment was performed in all patients pre- and post-operatively to assess patellar height and tilt, trochlear dysplasia, osteophyte formation, degree of osteoarthrosis, axial alignment and chondral condition. Patellar height was measured using the Insall–Salvati method; a ratio over than 1.2 indicated a patella alta whereas a ratio below 0.8 a patella baja.

Pre- and post-operative MRIs were performed using a 1.5-T magnetic resonance scanner (Artoscan M, ESAOTE S.p.A.), with the following sequences: Sagittal T1 SpinEcho, Sagittal Short Time Inversion Recovery (STIR), and 3D coronal Shifting Artifacts Reordering K-Space (SHARK) and transverse T1 gradient echo. Evaluation of the chondral status was performed using the ICRS classification and the final decision whether to perform an ACI was always made intraoperatively. All radiographic data (X-rays and MRIs) were reviewed by an experienced musculoskeletal radiologist who was blinded to patients' clinical situation.

Results

Thirteen patients were operated with combined ACI and MPFL reconstruction. Ten patients with a minimum follow-up of 1 year were included in the study. The mean follow-up was 2 years (minimum 1–4 years) 3 patients with less than 1-year follow-up were excluded. At last clinical follow-up, all patients demonstrated a free range of motion and a negative apprehension sign. Three patients presented with a small joint effusion. An improvement of symptoms and function was found in all knees at latest follow-up. The results of the clinical scores are displayed in Table 1. The post-operative modified MOCART score for quality assessment of ACI on MRI was an average of 13.7 points ± 1.8 (11–16), with a complete fill of the defect in 80 % of lesions (Fig. 3a–c). Detailed results are displayed in Table 1.

Table 1 Subjective outcome scores (mean, standard deviation and range, significance level: $p < 0.05$)

Score	Preoperative	Post-operative
KOOS	67.3 ± 15.7 (45–88)	74.4 ± 16.9 (57–95) p = n.s.
IKDC	49.8 ± 14.3 (36–75)	63.9 ± 22.1 (34–93) p = n.s.
Lysholm Score	62.9 ± 14.8 (44–93)	74.1 ± 18.7 (48–99) p = n.s.
Kujala	60.3 ± 13.8 (45–84)	73.8 ± 25.1 (50–100) p = n.s.

Discussion

The main finding of the present study was that combined MPFL reconstruction and ACI is a good treatment option in recurrent patella dislocation with grade IV cartilage damage. No patella re-dislocation occurred and the ACI was successful in 80 % of patients according to the MRI. Subjective and objective scores improved but combined surgery is inferior to reports from the literature on MPFL reconstruction alone with intact cartilage.

MPFL reconstruction has been successful in stabilizing the patella after recurrent patella dislocation. Clinical results are good and the re-dislocation rate is low [3, 5, 8, 15, 18, 23, 24, 32]. Kohn et al. [15] examined 42 patients 2 years after MPFL reconstruction. Eighty-seven per cent of patients were (very) satisfied with the treatment, the IKDC improved to 80, the Kujala score to 85, and the Tegner score to 4.9. Steiner et al. [32] reported on 34 patients with trochlear dysplasia and MPFL reconstruction. 5.5 years post-operatively no re-dislocation occurred.

In contrast severe articular cartilage lesions after recurrent patellar dislocation are difficult to treat [4, 21, 30, 38] and microfracture, Pridie drilling or abrasion are of limited success [10, 11, 26, 31, 35]. The result may be formation of insufficient fibrocartilage and/or a subchondral bone plate hypertrophy [31, 33]. On the other hand, ACI develops hyaline-like cartilage and was shown to fill up full thickness chondral defects [1, 6, 7, 19, 26]. Therefore, it might be more suitable for posttraumatic full size cartilage lesions. In a long-term study, Peterson et al. [26] reported improvement of the Lysholm, Tegner and Brittberg–Peterson scores after ACI at the knee joint with a satisfaction rate of 92 %. Another long-term study was presented by Niemeyer et al. [19]. They reported the results of 86 patients 10 years after ACI at the knee joint. Seventy-seven per cent of patients were (very) satisfied with the surgery—however—the authors concluded that full restoration of knee function cannot be achieved with ACI [19]. Clinical scores in this present study were in the range of above reports on ACI but inferior to reports of MPFL reconstruction alone with intact articular cartilage. All patient scores improved from pre- to post-operative but improvement was not significant, indicating the complexity of the injury pattern.

In this present study, a complete fill of the cartilage defect after ACI was seen in 80 % of patients on MRI. The remaining 2 patients showed more than 50 % fill. Similar results were observed by Ebert et al. They evaluated 41 patients

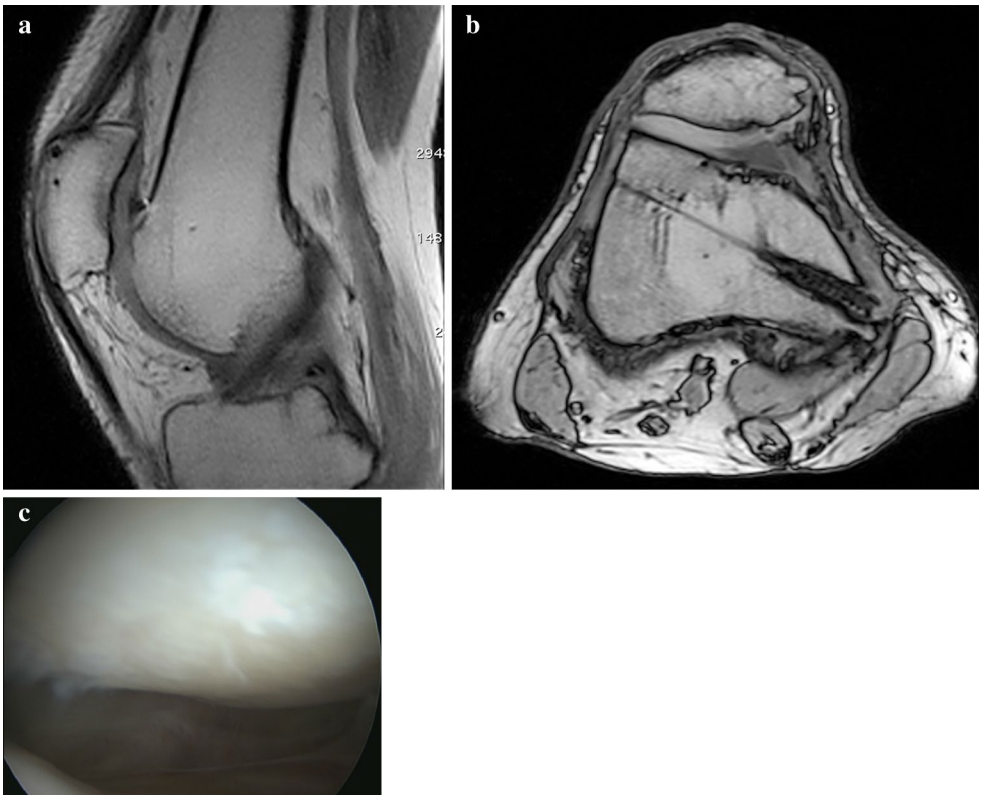

Fig. 3 Sagittal (**a**) and axial (**b**) MRI after MPFL reconstruction with gracilis tendon and retropatellar ACI. Good patella alignment. **c** Arthroscopic second look with regenerated articular cartilage. Same patient as Figs. 1 and 2

with 53 matrix-induced MACI and a follow-up of 5 years. Eighty-nine per cent of patients demonstrated good to excellent fill of the cartilage defects on MRI [6]. A second-look arthroscopy performed in one of our patients reconfirmed a complete retropatellar cartilage regeneration with good integration to the surrounding cartilage shoulder (Fig. 3c).

Clinical reports of combined patella realignment with ACI are rare. Usually, surgery is focused on distal bony tubercle transfer. Mid-term results of MACI with distal realignment are reported by Gigante et al. [9]. The authors assessed a significant improvement of the knee function and activity levels. Gillogly et al. [10] reconfirmed above findings. A systematic review including 11 studies was performed by Trinh et al. [36]. The authors reported three studies directly comparing isolated ACI and ACI with combined distal realignment [14, 25, 37]. Combined surgery showed significant better clinical improvement then ACI alone.

There are some limitations to the present study. The number of patients was small but such combination is often not addressed and the cartilage lesion on the patella is not treated. More patients would increase the power of the study to provide a better clinical picture of the population being sampled. This underlines the need for larger studies and the need to differentiate between relevance and significance in the interpretation of the data. Furthermore, this is a case series without control group, e.g. MPFL reconstruction or ACI alone.

Conclusion

This study introduced a new minimal invasive approach of arthroscopic ACI combined with MPFL reconstruction. Clinical results were good and the procedure can be recommended in complex cases with patellofemoral dysplasia, recurrent patella dislocation and severe cartilage damage. The combined surgery is necessary to correct the instability and to optimize the patellofemoral alignment for good cartilage recovery. All subjective and objective scores improved and no patella redislocation occurred. Cartilage regeneration was successful in 80 % of patients according to MRI criteria.

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